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Franklin Institute.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on the best modes of Paving Highways.

The Committee on Science and the Arts, constituted by the Franklin Institute, of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the following portion of a joint resolution of the Select and Common Councils of the City of Philadelphia, passed January 5th, 1843, to wit: "Resolved, That the Franklin Institute, be requested to communicate to Councils, any information they may think proper, in relation to the best modes of paving highways," REPORT thereon as follows:

That they entered upon the subject referred to them, in February last, that, at various meetings since, they have discussed numerous questions connected with the subject of paving, and that they have received testimony relative thereto, from a number of persons whose opinions are entitled to respect, and who appeared, by request, before their sub-committee.

With the view of setting out the results of our labors with greater perspicuity, we shall divide the subject into eight sections, treating, in the first place, of the leading pavements in use, and, ultimately, of those which seem most suitable to Philadelphia, to wit:

SECTION I. *Preliminary Observations.*
" II. *Asphaltic Pavements.*
" III. *Wooden Pavements.*
" IV. *Stone Pavements.*
" V. *Pavements suitable to Philadelphia.*
" VI. *Plans and Specifications of the Pavements Recommended.*
" VII. *Superintendence and Mode of Executing the Work.*
" VIII. *Concluding Observations.*

Without entering particularly upon the subject of *footways*, we shall, in discussing the matter in hand, limit ourselves chiefly to a consideration of street pavements, fit for the internal intercourse of cities; neither do we propose treating of the merits of the various modes of constructing roads, since many of the maxims of roadway engineering, though extremely judicious, when applied to highways *between cities*, are, to a great degree, inapplicable to streets *within them*.

Section I.

Preliminary Observations.

Since the thirteenth century, when regular pavements appear to have been commenced, within the limits of the leading cities of Europe, numerous plans have been projected, by ingenious men, for the amelioration of the public streets, and not a few patents have been procured in France and England, having, for their objects, improvements in the constructions of pavements, or the application of new materials to that use.

But as it is not our intention, either to enter into the early history of paved roads, or to attempt a record of the innumerable projects, both useful and abortive, which have been from time to time brought forward for the improvement of highways, and, particularly, of streets; we shall dispense with historical detail, and confine ourselves to a discussion of those species of pavements which have, of late years, the most engaged public attention, or have been the most in use.

These may conveniently be divided into three general classes, namely, *Asphaltic Pavements*, *Wooden Pavements*, and *Stone Pavements*.

From these, our deliberations have led us to select certain modes of paving, which would seem to be proper for Philadelphia, and which, in due course, we shall come to describe.

A good pavement ought to combine stability, and moderate smoothness of surface, with facility of removal and replacement, and be as free as possible from noise and dust.

To secure these important requisites, and, at the same time, to establish a completely stable foundation for pavements, is extremely difficult, if, indeed, it be not to a great degree, *impracticable*.

For, in consequence of the underground works of modern cities, such as sewers, gas pipes, and water conduits, to which access at all points must be allowed, for the purposes of repair, and attachment; the pavements of streets, must, if possible, combine with superficial goodness, such facilities of removal and replacement, as may enable the subterranean works to be reached at will, without serious impediment.

Unfortunately these conditions, which appear to exercise a paramount control over the streets of modern cities, absolutely preclude the employment of *concrete*, or *mortared masonry*, for the foundations of pavements; and also forbid the use of a very adhesive cement, between the paving stones themselves. Since all these methods, though beyond any question, of high importance to the

formation of permanent pavements, *such, for instance, as the celebrated Roman ways*, appear to be inadmissible, from the fact, that they would make extremely difficult, if they did not entirely cut off, the necessary access to the underground works of the city.

It is these preliminary considerations which have prevailed with us, over a strong desire to suggest the use of *concrete foundations*, in which, upon well drained ground, we have entire confidence, and which would otherwise have been recommended by us.

A thorough system of under drainage, is of great importance to the stability and success of pavements, and the *sewage* of every great city ought, certainly, to be as carefully planned, and, eventually, almost as thoroughly carried out, as the system of the water conduits usually is.

The leading cities of Europe appear to be now sensible of the important influence exercised by a good sewage, upon the health and comfort of their inhabitants, and the stability of their pavements.

The intelligent gentlemen who testified before us, unanimously concurred in representing the superior durability of the pebble pavements, in those streets beneath which sewers run; and, in point of fact, that the surface water should be rapidly drained off in wet weather, and not be allowed to run long distances over the surface, and sink into, and saturate the undrained bed of the pavements, seems to be indispensable to their durability, and to the easy maintainance of a regular surface.

That Milan is one of the best, or, perhaps, the very best paved city in Europe, is as much owing to the fact, that every street has its sewer, with openings at short distances to receive the surface water, as to the system of paving employed, or to the mildness of the climate there.

An additional reason for the success of the street pavements in the Italian, Austrian, and other cities of Europe, may, however, be found in the fact, that, with the exception of London, Paris, and a few others, the travel upon the highways there, within the limits of the several towns, is far inferior in weight, and destructive action upon pavements, to that for which the highways of American cities must be planned, and to which they are continually exposed.

Section II.

Asphaltic Pavement.

We learn from the "*Papers on Practical Engineering*," published for the use of the engineer officers of our army, under the direction of Col. J. G. Totten, Chief Engineer, and from other sources, that the bituminous mastic, commonly called the *Asphalte of Seyssel*, which appears to have acquired as high a reputation as any other composition of this nature, consists of a bituminous limestone, found in the Jura mountains, on the eastern frontier of France.

This stone is first roasted, then reduced to powder, and finally mixed up with about seven per cent. of mineral tar, or bitumen extracted from a mineral compound, called the *molasse*, which yields from fifteen to eighteen per cent. of mineral tar, when treated with boiling water.

"This tar, and the prepared calcareous asphaltum, are thrown together in the proportion of 93 per cent. of the latter, to 7 per cent. of the former, and thoroughly incorporated, by stirring the mixture in iron caldrons, while hot."

The success which attended the use of the *Asphalte of Seyssel*, and its kindred bituminous mastics, in the construction of footways, and other similar surfaces, to which they have, of late years been advantageously applied; naturally produced in the minds of many, a desire to have them used in the formation of highways for carriages; and accordingly, a pavement composed of fragments of quartz, cemented together by a very adhesive bituminous mastic, was laid in 1837, at the entrance of the "Place de la Concorde," in Paris, where it became immediately subjected to a prodigious travel, and for a short time it answered well, but ultimately proved to be a decided failure, and has since (we believe) been replaced by squared granite blocks.

M. Partiot, Chief Engineer, and Director General of Roads and Bridges, in France, has stated the cause of the failure of the bituminous pavement in the "Place de la Concorde" to be;

"That the contractor erroneously considered that his bituminous mastic was capable of resisting *the direct action* of the wheels, and horses' feet."

"This mastic which attaches itself very strongly to the stones, *should be used only for cementing them together, so as to form one solid block, but it should not be visible, the stone alone being seen on the surface.*"

"The stones of this pavement were not placed near enough together, and the intervals were filled with bituminous mastic, which is not capable of resisting the friction, so that the joints opened, and the surface of the pavement became rutty and uneven, *after only six months use.*"

We may here remark, in corroboration of the above, that the experience had in the application of the Asphalte of Seyssel, as it has been compounded, and used for floors and footways in Philadelphia, (which have been closely examined by the committee,) and the ease with which it may be indented, by moderate pressure upon small surfaces—such, for instance, as the feet of chairs—sufficiently indicates that this material, either alone, or combined with stones, may not be successfully applied to carriage ways, where its surface is exposed to the action of wheels, and to the feet of horses, as in a street, even if its great expense did not present an insuperable barrier to its adoption.

M. Partiot, the engineer above quoted, has expressed an opinion highly favorable to the use of bituminous mastics, *as a cement*, for uniting stones together in paving; but we need scarcely say, that if it is to be used in that manner alone, merely to form a bond of union, however good, between the stones of a paving, which are themselves entirely relied on to carry the passing weights, and to withstand the wear and tear of the travel, *the very name of bituminous, or asphaltic pavement becomes a misnomer;* since that term would certainly imply, that the asphaltic mastic was itself the predominating material,

instead of being the mere cement *between* the predominating materials; in which mode alone, it has been justly said, that *asphalte* can successfully enter into the composition of a pavement, designed for the use of heavy carriages; and even in that mode, it would probably cement the stones together so strongly, as to render the access to the underground works of the city, difficult, troublesome, and, therefore, be *objectionable.*

The various *asphaltes,* though they have been made very much the objects of speculation abroad, by numerous joint stock companies, (some of them fraudulent) and by a great many patentees, and, consequently, have had their utility, and proper scope of application, greatly exaggerated by interested parties, are, nevertheless, very useful, though expensive, materials in construction.

Asphalte has been very successfully employed in military works, as a water-proof covering for the vaults of casemates, the floors of barracks, the roofs of military buildings, the footways of bridges, and other similar purposes, in Military Engineering.

It has also been used, to some extent, in the cavalry stables in France, but has not been applied in those of the Empire of Austria, though proposed for that purpose, and examined by the military engineers with that object, as we are informed, by an officer of that corps, temporarily resident here.

The footways of the Pont Royal, at Paris, formed of Asphalte, $\frac{52}{100}$ of an inch thick, required to be renewed within *five years,* though M. Partiot, in a careful calculation, had previously computed its period of duration at *seven years.*

Nevertheless, *asphalte* may be made exceedingly useful for footways, if, by a more sparing use of the mineral tar in its composition, it be made sufficiently stiff to resist the summer's sun, without injurious softening; it will, however, be much more expensive than the common "*herring-bone*" pavement of brick, so much employed in the American cities.

Finally, from the considerations above recited, *we conceive, that Asphalte, in any of the forms in which it has yet been used, cannot be recommended for the carriage ways of cities:* and, in support of this opinion, we may mention, in conclusion, that the *asphaltic pavements,* which, by way of trial, were laid some years since, in Oxford street, and in the Vauxhall road, in London, have entirely failed, or proved unsuccessful.

Section III.

Wooden Pavement.

This species of pavement, like that of asphalte, discussed in the preceding section, may be regarded as an innovation of the present century, since it is but recently that either have been introduced into our cities, as a part of the general system of paving.

Although a good deal of experience has now been had, in the use of *wooden paving,* both here, and elsewhere; there is yet a great diversity of opinion, as to the results, even amongst those who have for years daily witnessed the action of such pavements.

Discussions, warm, and even acrimonious, have been for some

years going on in London, and are still in progress, both in fugitive pamphlets, and in scientific periodicals, relative to the merits and demerits of pavements of wood, of which large surfaces are now laid within the limits of that great metropolis.

Within the course of last year, forty thousand superficial yards, (or an extent nearly equal to thirty-six of our east and west squares,) were laid down by a single company—the Metropolitan—which has for some years been organized, with the view of introducing a particular form of wooden pavement into London; the same, in fact, as that laid in Walnut street, east of Third, and known as the plan of the Count De'Lisle.

We learn, on the one hand, that the authorities of Mary-le-bone Parish, in London, after long and patient trial, in Oxford, and other streets, and after much deliberation upon this subject, *have recently resolved to lay no more wooden pavements for three years:* and, on the other hand, we find it alleged, that this decision has not been well grounded upon the facts developed by the experience of London; and we further find, that some of the original opponents of wooden pavements, have since recanted their opposition.

With this maze of conflicting testimony before us, it is difficult to arrive at the true state of the case elsewhere; but it is quite certain, that wooden paving has not fulfilled the expectations of its projectors, though it was scarcely to have been anticipated, that it would have fully done so.

Wood paving, undoubtedly, possesses some peculiar advantages of a very decided character, amongst which, we may name the almost total extinction of noise—the reduction in the wear and tear of vehicles, arising from its regularity, and elasticity of surface—the ease of draught upon it—its cleanly condition—and the surprising manner in which it resists *mere wear.* On the other hand, besides its original expense, and want of durability when the wood is employed in its natural state, a very leading objection against the use of wooden pavements in cities, is to be found in their *slipperiness,* or the insecurity of the horses' foothold thereon, especially in wet weather.

So serious an objection is this, in the humid climate of London, that a leading scientific periodical, though, itself, favorable to wooden paving, describes the slipping of the horses upon such pavements there, after a shower, as being "*truly awful.*"

It seems that at such times it is difficult to stop an omnibus, for if the horses are suddenly pulled up, when in a trot, they slide forward, and often fall down, with injury to their harness and themselves.

This objection, though not so serious in our drier climate, applies, nevertheless, to a considerable extent, to the wooden pavements of Philadelphia, as many of our citizens have noticed.

Attempts to obviate this difficulty in Europe, have been productive of many patents, designing to provide a more secure foothold for the horses, by cutting the tops of the blocks, or their upper edges, so as to form a series of grooves, striating the surface of the wooden pavement in various directions transversely, or diagonally, according to a plan fixed by each patentee.

With regard to this remedy, it must be remarked, that if to furnish a stronger foothold, and avoid accidents to horses, it becomes necessary to cut the surface of a wooden pavement into grooves, besides the expense of that operation, two of the leading advantages of such paving, namely, ease of draught, and absence of noise, will be to a considerable extent impaired.

To maintain a regular and even surface with a wooden pavement, without which it could claim but little advantage, it seems to be necessary that it should be placed upon a very stable foundation; indeed, the Civil Engineer and Architect's Journal, in an able article advocating the cause of wooden pavements, admits, *that without a concrete foundation, to use wood for paving, would be a mere quackery, and a waste of money.*

Now, a concrete foundation, of proper solidity, presenting a barrier against the necessary access to the underground works of a city, conflicts with the maxim set out in our preliminary observations, and is, therefore, inadmissible on that ground, to say nothing of its cost, if so laid. With regard to the durability of wooden pavements, experience in Philadelphia has shown that *about three years* is the limit of duration for pavements of *hemlock;* but those of *yellow pine* and *white cedar*, promise to have a somewhat longer period.

We learn that in Russia the wooden pavements require renewal at intervals of about five years; and judging from sufficient experience of the decay of the sleepers of rail roads, which, like pavements, are in contact with the ground, (though upon the side, instead of end grain,) we cannot hope that pavements of *oak, or pine wood*, would last, upon an average, *more than six or seven years, at the furthest.*

It must also be observed, that the blocks of wooden paving, being placed in conjunction with each other sidewise, become peculiarly liable to that speedy rot, which seems inseparable from the lateral contact of wood; since it may be everywhere noticed in construction, and, particularly, in damp situations, that wherever timbers are in close contact, as at joints, and intersections, *there the progress of decay is invariably more rapid,* and this well known fact, may, in part, account for the speedy decay, evinced by the wooden pavements of this place.

From this it appears to follow as a necessary consequence, that to render wooden pavements satisfactory, the timber must be, if possible, preserved from decay to such an extent, as will essentially prolong its durability.

It is important, then, in this connexion, that we should now consider some of the means by which the durability of timber may be prolonged, though we do not intend to describe, or even to mention, all the antiseptic projects devised, or tried.

William Chapman, of Newcastle, England, a civil engineer of distinction and experience, published at London, in 1817, a treatise "*On the Preservation of Timber,*" in which he recorded numerous experiments made by himself, upon different woods impregnated with various substances; and he also embodied most of the practical knowledge then extant upon that subject.

He states that as long since as 1792, it was proposed to soak timber in copperas water, with a view to its preservation; it having often been observed, that many of the timbers used about copperas works, acquired surprising durability, when frequently exposed to the action of a solution of that substance.

In this work, Mr. Chapman announced, *that all the metallic salts were, more or less, antiseptic in their nature, and that when timber was impregnated with them, they coagulated the albumen of the wood, and had considerable effect in preserving the whole from decay.*

This principle so explicitly set forth—that of coagulating the albumen of the wood, by a metallic salt, and thus forming an insoluble and indestructible compound—is precisely the one which sundry modern projectors have seized upon with avidity, and sought to appropriate to their own use by letters patent; but few of which, however, could successfully stand the test of a legal discussion, if Chapman's treatise were given in evidence.

It further appears from Mr. Chapman's work, that boiling timber for three or four hours in a saturated solution of green vitriol, (sulphate of iron, or copperas,) has long been in use in Sweden; that it is found very advantageous there in preserving wood from decay; and that most of the timber used in that country for carriages, is thus prepared. We doubt, however, the utility of *boiling.*

Mr. Chapman tried impregnating timber with solutions of lime, and with coal tar oil, but neither of these proved to be satisfactory defences against decay; and he observes, relative to impregnation with salts of iron, "that the acetous fermentation should take place in the sap of timber, before it be macerated in a solution of copperas;" and observing this precaution, he projected the preparation of timber for the Royal Navy on a grand scale, by immersion in saturated solutions of sulphate of iron.

He also tried numerous experiments, by immersing pieces of wood in solutions of various metallic salts, such as nitrate of silver, corrosive sublimate, sulphate of copper, sulphate of iron, *and of the two latter salts combined.*

Mr. Chapman drew from these experiments, the inference, that in coagulating the albumen of wood, "the sulphates of copper and iron were both effective, and nitrate of silver, and corrosive sublimate, decidedly so;" and hence, he concludes, that thorough impregnation with any of these metallic salts, would prove decidedly antiseptic in its effects upon timber; though from motives of economy, he gave a preference to the use of a saturated solution of copperas.

The treatment above described, was designed by Mr. Chapman, to be preventive of decay; but he also used, with decided effect, as a remedy for dry rot already begun, a wash composed of *hot solutions* of sulphate of copper, of sulphate of iron, and of both these salts combined.

Sir Humphrey Davy, many years ago, proposed, as the result of some examination, a wash of corrosive sublimate, as a remedy for dry rot.

All the above preservatives and remedies were mentioned by Tredgold, in 1824, in his able and widely circulated treatise upon Carpentry, by which work, a notice of these antiseptics was extensively spread amongst artificers.

Thomas Wade, in a work published in 1815, mentions "that timber may be impregnated to advantage, with any of the following sulphates, viz., of *copper, zinc, or iron.*"

Robert McWilliam, Architect and Surveyor, in a treatise on the Dry Rot, published in 1818, says, "that of metallic salts I have frequently used with success, (for the prevention of dry rot) the sulphates of *copper, iron,* and *zinc;*" and he finally concludes, from all his experiments and observations, "*that any mode of impregnation by which timber can be made close, solid, and hard, in its whole bulk, or in its parts, so as to make it repel air and moisture, will secure its durability.*"

John Knowles, Secretary to the Surveyors of the English Navy, in a memoir published many years since, enumerated various proposed preservatives for timber, amongst which were the sulphates of copper, iron, and zinc, corrosive sublimate, eleven salts of earths and alkalies, and two acids.

McWilliam, in the treatise upon Dry Rot, above mentioned, says distinctly, "that *various preparations* of different metals have likewise been used with success, (to prevent decay in timber) particularly those of *iron, copper, and zinc.*

Upon the ample basis afforded them by the investigations and remarks of the writers above quoted, numerous individuals have grounded patents, and sought the aid of their respective governments, to enable them to monopolize the use of several preservatives for timber, which had long previously been used, or suggested, by others.

Amongst these patentees, the most prominent, are Bill, Kyan, and Burnet, in England; and Earle, in our own country.

Bill's patent is, (we believe,) for the impregnation of wood, with a preparation of coal tar.

Burnet's patent is for impregnating timber with the chloride of zinc, aided now by exhaustion, and subsequent pressure.

Although timbers prepared by both of these patent processes, have been subjected to some strong tests with favorable results; and though Burnet's process has recently found some strenuous advocates, and is now being introduced upon a large scale into the English dock-yards, neither of them have, as yet, been very extensively employed.

The antiseptic processes generally known as those of Kyan, in England, and of Earle, in this country, appear to have acquired the greatest notoriety, and have probably been more extensively used, than any of the others.

Kyan's process, which, under the name of *kyanizing*, has even added a word to our language, consists of steeping timber in a solution of the corrosive sublimate of mercury, formed in the proportion of 1 lb. of cor. sub. to 5 galls. of water, and continuing the immersion for a longer, or shorter period, according to the dimensions of the stick of timber immersed.

Mr. Kyan appears to have taken out *two patents*, the first under date of March 31st, 1832, (see London Rep. Pat. Invent. vol. xiv, p. 276,) was mainly, *for the preservation of wood*, by means of corrosive sublimate: the second under date of September 22nd, 1832, (see Newton's Journal of Arts, &c., vol. iii, conjd. series, p. 86; and Rep. Pat. Invent. vol. xvi, p. 9,) was confined in its application to such vegetable substances, or fabrics, as *paper, canvas, cloth, cordage, &c.*

We have before stated, that the application of corrosive sublimate of mercury, to vegetable substances, as an antiseptic, had been, many years before, prescribed by Chapman, and Davy, and had even been directly applied, by the former, with success, to the preservation of wood; still, as the efforts of these distinguished men had failed to attract the attention, or command the confidence of the public, to an extent sufficient to introduce this antiseptic into use amongst practicians; Mr. Kyan deserves credit just so far as he was the means of reproducing the invention, demonstrating its utility anew, and finally of introducing it into constructions at large, and rendering it generally available for practical purposes.

Nevertheless, that Mr. Kyan was enabled to obtain a patent for this process at all, is probably owing entirely to the English practice of granting letters patent for anything where the fees are paid, and leaving to the courts of law alone, the determination of the whole question of validity.

It is not probable that Kyan's process, as it is commonly called, can be sustained under the American general law of patents, since solutions of corrosive sublimate had been successfully used for the preservation of wood by Chapman, many years before; and in the language of our law, "*had been described in a printed publication, in a foreign country;*" that, therefore, the composition of matter employed by Mr. Kyan, had been, in the words of the same section, "*known, or used by others, before his discovery, or invention thereof;*" and, consequently, under the act of Congress, of July 4th, 1836, to which we now refer, a patent therefor, would seem to be untenable.*

We may here observe, that McWilliam has made the valuable observation, that the trees which are the most readily and advantageously impregnated with salts of iron, are those abounding with "the astringent principle (tannin and gallic acid):" whilst the "*coniferae*," or trees of the pine family, being of a resinous, and not of an astringent nature, are but little affected by antiseptic preparations of iron.

This shows the propriety of confining the application of salts of iron mainly to such timber as *oak, elm, chesnut, ash, &c.;* and it may probably account for the very slight effect produced by the iron antiseptics upon resinous timber, as may be illustrated by the failure of Earle's process, as applied to hemlock pavement in this city.

In Earle's process for preserving timber from decay, for which letters patent of the United States, issued upon the 20th of September, 1838, the claim of the inventor is substantially as follows:

"For the boiling of timber in a solution of sulphates of iron and copper.

* Nevertheless, Mr. Kyan, by special act of Congress, obtained a patent from the United States, under date of June 23rd, 1838, (see vol. xxiii. of this journal, p. 396, with the Editor's remarks.)

"I do not claim the saturating of timber by a solution of sulphates in water when applied cold, but confine my claim to boiling it in that solution from two to five, or six hours, or more."

The only novelty of this process of Earle's,* consists in *the boiling of the timber in* the particular solution named, that solution itself having been used in a cold state, for the same purpose, by Chapman, prior to 1817; and having also been long since applied *hot*, as a wash to preserve timber from decay, or to cure the dry rot.

The utility of boiling timber is very doubtful, and by McWilliam, in his treatise upon Dry Rot, it is pronounced "*to be positively injurious.*"

It appears to us that the antiseptic properties of metallic salts, are nowise impaired by employing them in cold solutions, and that their activity cannot be much—if it be at all—augmented by the operation of *boiling*, which increases the trouble and expense, without, as far as we can perceive, attaining any valuable end, not equally attainable by immersion in saturated solutions at ordinary temperatures, particularly if exhaustion and pressure be used.

In addition to the above modes of augmenting the durability of timber, impregnation *with oil*, under great pressure, has been proposed by M. Breant, and some successful experiments with wood thus prepared, have been tried in the flooring of a bridge in France.

A powerful hydrostatic pressure, following a previous exhaustion, has been found useful in promoting a thorough impregnation of timber with metallic salts in solution; and impregnation with *kreosote* has also been proposed by M. Moll, a German mechanic.

Recently a cheaper metallic salt, and a different and superior mode of thoroughly impregnating the timber, has been proposed for use by M. Boucherie, and illustrated by many experiments of a conclusive nature.

A very interesting account of this process, translated from the French, by Professor John F. Frazer, may be found in the Journal of the Franklin Institute, for 1841.

M. Boucherie's method is to employ the impure pyrolignite of iron, as the antiseptic salt of impregnation, and to cause it to insinuate itself into all the pores of the wood, by means of the singular power of aspiration, developed by the sap of newly felled trees.

M. Boucherie's plan, in brief, is to fell the trees, and lop off all the branches except the top; then to connect the lower end of the trunk, by means of a water-tight bag, or any other suitable means, with a reservoir containing a saturated solution of the impure pyrolignite of iron; then the sap being gradually exhaled from the leaves remaining upon the upper branches, the ferruginous liquid is drawn up into the body of the tree, until, in a few days, it reaches the uttermost branches, and fills all the capillary tubes of the timber, coagulating, and solidifying in its progress, all the albumen of the wood, and greatly augmenting its durability, by rendering it, in the words of McWilliam, "*so close, solid, and hard, as to repel air and moisture.*"

Such is the force with which the sap is propelled forward through the pores of the body of a tree, in consequence of the exhalation from

* *Boiling* wood in lime water, with the view of protecting it from decay, was also patented here, by Ringgold and Earle, August 6th, 1838.

the top, when newly felled, that Dr. Hailes is his vegetable statistics, published about a century ago, mentions the case of a freshly cut vine branch, which being plunged at its lower end into mercury, drew that metal up into its tubes, to the height of *thirty-eight* inches; thus actually evincing a power superior to that with which the atmosphere acts against a vacuum!

From the satisfactory character of the numerous experiments adduced by M. Boucherie, there is strong reason to believe, that this process will be very efficacious, and as it is not expensive, it ought, certainly, to receive as full, fair, and speedy a trial in this country, as it has already had in France.

In point of fact from the results of experiments which have been made, we are led to infer, that a thorough impregnation with the salts of iron, may answer the end of considerably prolonging the durability of timber, and probably render unnecessary, the application of the more expensive salts of copper, or mercury, which seem to be more active antiseptics.

In addition to the above, we have gathered from the various English works on patents, and from the Civil Engineer and Architect's Journal, the following information, which may prove interesting in this connexion.

Murdock's Patent, May 2nd, 1791; proposed to preserve timber from decay, by a paint of sulphur, arsenic, and zinc.

Newmarch's Patent, February 25th, 1826; proposed to preserve timber from decay, by boiling it for three or four hours in a solution formed of the following materials, mixed in the proportions stated, viz., 3 oz. of sulphate, or acetate of copper, 3 oz. of white arsenic, and 1 gall. of linseed oil.

A mode of seasoning timber by placing it in an iron tank, resembling a steam boiler, and then exhausting the air from within, was patented by Langton, in 1825.

Mr. Carey, of the Royal Navy, in 1785, noticing the good effects proceeding from the plan then, as now, employed in America, of salting vessels whilst on the stocks; and, further, observing that whale ships were seldom attacked by dry rot, he conceived the idea of preserving vessels from decay, by filling all the spaces between the timbers, whilst under construction, with a mixture of oil and salt, thickened up to a proper consistency, by the addition of powdered charcoal, itself a powerful antiseptic.

With this compound Mr. Carey filled all the openings between the timbers of two vessels that he built in America in 1785, and in evidence of its efficacy, he states that in the year 1816, *or thirty years after*, he met with one of these, a brig of 200 tons burden, in the harbor of New York, which was still sound in nearly all its timbers, as he ascertained by boring many of them.

Sir William Burnet, in 1836, suggested, and was instrumental in testing on a large scale, a more effectual mode of causing antiseptic solutions to impregnate timber, than mere immersion was found to be;—this was by piling the wood within a suitable iron tank, then exhausting the tank to a partial vacuum, represented by a pressure of

about 5 inches of mercury, then admitting the antiseptic solution; and, finally, subjecting the fluid to a pressure of about 100 lbs. to the inch above the atmosphere.

This method, with the chloride of zinc, employed as the antiseptic, has found some vigorous advocates, and is now beginning to be extensively applied abroad.

A leading objection urged against Kyan's process, is that the deutochloride of mercury employed, *does not* coagulate the albumen of the wood, or vegetable tissue, into an insoluble compound, since kyanized sails have had the corrosive sublimate so thoroughly washed out of them by the exposure of a single voyage, that an application of the usual chemical reagents failed to detect a trace of mercury.

Some wooden piles, also, which had been kyanized, and used in a sea work, were cut to pieces in a short time, by the "*teredo navalis*," or ship worm; thus rendering it probable, that in those cases, also, the corrosive sublimate had been washed out.

On the other hand it is certain that on some of the railways, kyanized sleepers have far outlasted similar sticks of unprepared timber, and are still sound.

Sir William Burnet's process of impregnating wood, &c., with a solution of the chloride of zinc, aided by exhaustion and pressure, is said to be free from the objection urged against that of Kyan; it seems to be superseding *kyanizing*, in the favor of the English Commissioners of the Admiralty, and nearly all the naval timber, sails, cordage, &c., to which antiseptics are there applied at present, are treated by Burnet's zinc antiseptic process, under the name of *burnetizing*.

One of the most recent antiseptic projects, is that of a Mr. Payne, who, calling both exhaustion and pressure to his aid, first impregnates timber with a solution of sulphate of iron, and afterwards with muriate of lime, which is said to attain the desideratum of forming an insoluble compound within the interior of the timber, and by its means, preserving the wood from decay.

We have entered thus at length into the subject of preserving timber from decay, because, without some efficacious means of augmenting its durability, the employment of wood as a material for paving, will, of necessity, be precluded by its expense, even if other objections should be overcome; and, because, with the use of proper antiseptics, we should still hope, that in particular situations, where absence of noise is paramount to all other considerations, wooden pavements may yet be used with advantage.

Locust and Red Cedar, which are justly esteemed as the two most durable woods accessible to us, have both been suggested as materials for paving streets; but it appears to us, that pavements of either of these, would probably be much too costly for ordinary use, even if the latter were sufficiently hard to withstand the action of the travel with success, or if, in both, the slipperiness of their surfaces could be obviated.

As an evidence of the costly character of the wooden pavements which have yet been laid in Philadelphia, we may refer to the following:

1. The hexagonal hemlock pavement, laid some years ago, in Chesnut street, between Fourth and Fifth, cost $2.50, per square yard; *and was decayed to such an extent, as to require renewal within three years.* This wooden pavement has recently been replaced by squared stone blocks, upon a gravel foundation, and laid upon the rectangular system.

2. The squared block wooden pavement, in Third street, north of Spruce, cost about $2.25 per square yard; and after *three and a half years use*, the hemlock portion of it is very much decayed, and needs renewal, while the heart yellow pine portion is still in apparent good order, though presenting strong symptoms of decay. This pavement was laid in September, 1839, and the hemlock portion, now patched in many places with pebble paving, will probably require removal in the course of the present year, 1843.

3. The wooden pavement of white cedar, formed of oblique prisms (doweled together) upon the Count De Lisle's plan, which was laid in Walnut street, east of Third, in 1840, cost $1.75, per square yard, and is still in good order.

4. The cubical hemlock pavement, in front of the State House, in Chesnut, between Fifth and Sixth streets, which was laid in July, 1839, cost about $2 per square yard; and after but four years use, had so extensively decayed, that it has this year (1843) been replaced by a cubical pavement of stone, laid upon the diagonal plan.

5. The squared hemlock block pavement, laid in Spruce street, between Tenth and Eleventh, cost about $2 per square yard of surface; it was laid in November, 1839, and though exposed to very little travel, it now exhibits unequivocal symptoms of speedy destruction.

In three of the above instances, viz., in Third street, north of Spruce, in Spruce, from Tenth to Eleventh, and in Walnut, east of Third, the expenses of the wooden pavements were partly borne by voluntary private subscription, as an inducement to the authorities of the city, to use wood in those streets.

The hemlock, which has been chiefly used in Philadelphia, for the wooden paving, is certainly the most unsuitable timber that could have been employed for such a purpose; nevertheless, its very rapid decay shows, but too clearly, the great liability of wood, in general, to rot under such circumstances; a consequence of which is, *that without the economical and successful application of antiseptics, to prolong its durability, wood must be given up as an economical pavement, unless future experience should indicate some wood, combining cheapness, with durability.*

The necessity of applying preservatives to the timber used in wooden paving, is strongly inculcated by the expensive experience of Philadelphia; and it is, consequently, a matter of regret, that such indifferent success has attended the application of Earle's process, to the first fifty feet of wooden pavement now laid in Sixth street, south of Chesnut; *many of the blocks of which are much decayed at this time*, though, by way of apology, it is asserted, that they were originally affected by rot, prior to being boiled in the solution of the sulphates of copper and iron, as prescribed in the patent of Dr. Earle.

It has been alleged with some truth, that wooden paving resists the wear and tear of the travel, in an equal degree with some stones that have been employed, but this assertion requires limitation; for although it is true to an unexpected extent, whilst the timber remains *perfectly sound*, yet the moment the coherence of its parts becomes impaired by the progress of decay, it yields to the travel with extreme rapidity, and quickly wears in holes: this may be witnessed in most of the older wooden pavements, where the middle of the carriageway, being the most exposed to travel, has worn into deep unequal hollows, whilst next to the gutters, where they are less exposed to the action of the wheels of passing vehicles, the blocks retain their figure well, and though not less extensively decayed than the rest, they do not show it so soon.

Now, inasmuch as wooden pavements undoubtedly possess advantages which would render them useful at some points, and as experience abroad has not yet *definitively* decided upon their merits, we are not disposed, at this time, to condemn them entirely; but we would recommend to the Councils of Philadelphia, *to abide the result of the extensive practice of London, and other cities, where wooden pavements are now undergoing ample experiments*, and in the meanwhile—if they see fit—to lay, for trial, say *three* experimental intersections, in some well traveled street, with wooden pavements, as follows:

1. Of sound *Locust* timber.
2. Of sound and seasoned *White Oak*, prepared by immersion for one month, in a saturated solution of sulphate of iron.
3. Of *White Oak* prepared by Boucherie's process.

As no patent right would interfere, these experimental intersections, covering but little upwards of two hundred superficial yards in all, would cost but a small sum; and being laid in an economical manner, upon a pebble pavement foundation, (as specified in the Sixth Section following, for pavements of squared stone,) their construction would enable an estimate to be formed, of the probable expense of good wooden pavements upon larger areas; whilst, in a few years, they would clearly show what may be expected from pavements of wood, either of a quality well known for durability, or of other timber impregnated with antiseptics.

Finally, in consequence of the slippery nature of their surfaces, of their deficient durability when of ordinary timber, of their expense, immediate, or ultimate, and in view of the results of experience, as far as they have become known to us, we are reluctantly impelled to the conclusion, that though their use may be proper in some detached situations, *wooden pavements ought not, at this time, to be recommended as a part of a general system of paving, for the city of Philadelphia.*

In support of the above conclusion, it is proper to state, that since the preceding portion of this report was written, we have learned that the authorities of the city of New York, have determined to take up their decayed wooden pavements, and relay them with *stone;* whilst

we perceive that some of the public prints of that place, in deploring the necessity of this renewal, declare that the wooden pavements there, have proved a signal failure.

We regret to learn that the experience of Boston, with regard to the deficient durability of pavements of wood, has been almost as decisive and unfavorable, as that of Philadelphia and New York; and it is also corroborative of the propriety of the opinion we have ventured to express *against the employment of wooden pavements here at the present time.*

Section IV.

Stone Pavements.

We now come to the consideration of stone pavements: traces of these, of the highest antiquity, are to be found in Egypt, but they are supposed to have been first employed as a regular system, by the Carthagenians; and after the subjugation of Carthage by the Romans, they were brought to the highest degree of perfection, by that conquering people, and pushed by them for military purposes, and with a characteristic energy, even into the remotest provinces of their mighty empire.

The Roman highways of dressed stone, usually polyangular, fitted with surprising neatness. and placed upon a solid foundation *of concrete, or masonry*, have formed the prototypes of modern constructions of this nature, and are scarcely to be surpassed in durability: some of them, in fact, being now in use, after having successfully withstood the travel and wear of fifteen centuries; though it must be remarked, that where such is the case, the travel is not to be compared in weight, or destructive action, with that which continually traverses the streets of modern cities.

The stone pavements in common use, may, with propriety, be considered under three separate heads, namely:

1. *Of pavements of dressed stone.*
2. *Of pebble pavements.*
3. *Of stone tramways combined with pebble pavements.*

All of these systems have some common points which require attention, and amongst these, is *the foundation*, which Mr. Richard Lovell Edgeworth, in his well known treatise upon Roads and Carriages, justly remarks, "is in all pavements the first thing to be attended to."

The common practice here is to make the foundation consist of about one foot in depth of gravel, thrown loosely into an excavation, and not otherwise consolidated, than by the travel of the carts, in which it is brought; this foundation, scarcely possessing sufficient strength for the most obscure and least traveled streets, is decidedly insufficient, when applied to the great thoroughfares.

Sir Henry Parnell, in his able treatise upon Roads, which has become a text book in these affairs, states that "the chief defects of all pavements arise from neglecting to give the stones a proper shape, and to construct a substantial foundation to support them."

The first question to be determined then, is, what foundation should be employed in pavements here?

We have already shown, in our preliminary observations, that *concrete*, and other similar foundations of great solidity, are inadmissible, for reasons that seem to be sufficient.

What then shall we employ for a foundation, which shall at once present sufficient solidity, and yet will not cut off the access to the underground works of the city?

It has been satisfactorily shown in the case of Fleet street, in London, referred to by Sir Henry Parnell, that a mere mass, or bed of broken stone, even if 12 or 18 inches in depth, when loosely thrown in, and leveled off, is totally insufficient to form a good foundation for a pavement; and that the only mode in which broken stone foundations can be made to succeed, is by forming the metal into a regular macadamized road, and consolidating it under the travel in *thin layers*, as is usual in such cases.

Sir Thomas Telford, the distinguished engineer, in his report upon the street pavements of the parish of St. George, says that, "as relates to the metropolis generally, I am persuaded that a bed of cleansed river ballast, *(gravel stones)* about six inches in thickness upon an average, will be found to answer the purpose (of a foundation)."

But in 1833, he remarked upon this same point, "that on reconsidering this subject, I am of opinion that this quantity of ballast will not make a sufficiently strong bottoming, and that nothing short of twelve inches of broken stones, put on in layers of four inches each, and then completely consolidated by carriages passing over them, will answer the purpose."

Now, the formation of a complete macadamized road, as a foundation for a street pavement, as recommended by Telford, (though, undoubtedly, sufficient for the purpose,) would be both inconvenient and expensive, while from its solidity, it would present a serious obstacle to any excavations which might become necessary in the street.

But there is another mode of forming a foundation for a pavement, which seems to satisfy the conditions we have set out; and with regard to a similar plan, recommended by Sir Henry Parnell, that author makes the following remarks:

"In those streets where there is a constant passing of carriages, both night and day, such as the Strand, Fleet street, Holborn, Cheapside, Piccadilly, and Oxford street, (in London) the foundation for the pavement, should be *a sub-pavement*, made of old paving stones, or any kind of coarse stone; and this should be laid upon a bed of broken stones. This mode of paving is in use in Paris. *In the autumn of* 1825, *for instance, the old pavement of the Rue Dauphine was taken up and relaid on a bed of gravel to form the foundation for the new pavement. This practice has proved completely successful.*"

This mode of laying new pavements upon foundations formed by a sub-pavement, made of the stones of the old one, is still practiced with success, in the streets of Paris.

In view of all the experience upon this point, the best mode of forming the foundation of a dressed stone pavement—suitable for the principal thoroughfares of a great city—which, after much considera-

tion, has suggested itself to us, as giving sufficient stability, without involving too great an expense, or being attended with any serious inconvenience, *is to use a common pebble pavement for that purpose:* while, in other streets, where the travel is less, and where the pebbles themselves are retained as the paving, *the foundation of gravel may still be employed, if it be carefully consolidated in layers by rolling.*

The subject of *drainage* is intimately connected with that of foundations, and will now require our consideration.

A good drainage for the foundations of the pavements of a city, presents difficulties unknown in roadway engineering: for upon well constructed roads, mitre drains of rubble stone beneath the road surface, are made at proper intervals, to open into the side ditches, whence the water is readily drained away; and, by this means, the bed of the road can be maintained in a comparatively dry, and firm state: whilst the foundations of a street pavement, not readily admitting of this effectual lateral drainage, are much more difficult to be kept in good condition.

In many of the streets of cities, *sewers* have been omitted, in consequence of their expense, and hence much of the drainage *is merely superficial.*

It results from this, that the water which is shed from the houses, and from the sidewalks, being thrown into the depressed carriage ways of the streets, and combined with the downfall upon their surfaces, has often to run considerable distances along them, before it finds entrance to a sewer; this gives time for a great deal of the drainage water in its lengthened course, to soak down through the joints of the paving—thus saturating the foundations of the pavements, and, as a necessary consequence, rendering them weak, and liable to be broken up.

This is a great evil, and merits the closest attention of the authorities of a city, since a thorough system of underdrainage—whilst of high importance in a sanatory point of view—seems to be indispensable to the complete success, and stability of pavements.

Such, in every aspect, is the importance of a good sub-drainage, that we cannot refrain from recommending to the authorities of Philadelphia, *the immediate planning, and the gradual introduction of a complete system of sewage,* for it will not be until an underground drain exists in every leading street which has a retentive sub-soil, that the system of pavements can be rendered complete.

The mere underdrains of streets, or subordinate sewers, out of the natural lines of drainage, need not exceed two or three feet in diameter, the top being but three feet under the surface, having half brick openings occasionally, and being covered over with rubble stone, or brick rubbish, so as to admit of a free drainage, both direct and lateral.

Such underdrains may be easily located so as not to interfere with the gas, or water conduits, their expense would not be great, and if a comprehensive plan of sewage were but once adopted, and gradually put in execution, as the several streets of the city require repaving—

with the view of finally forming an underground drain, or sewer, in every leading street, which is not on porous ground—the annual outlay would be scarcely felt, whilst the improvement of our highways would soon be apparent; superior cleanliness would be insured, and the nuisances of transverse gutters, unstable pavements, and cellars wet by overflow, would quickly disappear.

Where sewers already exist under streets, a good underdrainage may be easily effected, by forming beneath the foundation of the pavement a longitudinal trench, some two or three feet square in section, directly above the sewer, filling the trench with rubble stone, (thus forming a blind drain) and causing it to communicate with proper apertures in the top of the sewer, by dry stone wells, at two or more points, in every square of its length.

Having thus considered the important collateral points of *foundation* and *drainage*, let us now proceed to a separate discussion of the several kinds of stone pavement.

1. *Of pavements of dressed stone.*—These pavements have for a long series of years, been employed for the principal thoroughfares in the leading cities of Europe; and in combination with pebble pavements, for the more subordinate streets, they have for centuries, formed the main part of the surfaces of city highways; although often rudely dressed, and badly laid, they have uniformly held the highest place in public estimation; and though of late years many projects have come up for superseding them by wood, or asphalte, yet since most of these attempts have proved abortive, it is probable that hereafter, as heretofore, uniform surfaces of dressed stone will be the most generally approved and used, in those great thoroughfares where smooth and durable pavements are an important desideratum.

When Mr. Telford was consulted in relation to the pavements of the parish of St. George, in London, he examined this subject with great care, and, with a commendable degree of caution, prior to forming his own opinion upon the matter in hand, he submitted sundry questions relating thereto, for the deliberation of the Civil Engineer's Institution, at repeated sittings, and the conclusions arrived at, by that very intelligent body, are thus stated:

"The result of these able, and very candid discussions, was *an unanimous resolution*, that whin, or granite pavement, of proper form and depth, laid on a sound bottom, *is preferable to any other mode for carriage ways* for the metropolis, and other large cities, in order to form a body of strength, adequate to bear the pressure and shocks of innumerable carriages, many of them conveying several tons."

Dressed stone pavements are, undoubtedly, very expensive in the first instance; and hence they ought only to be used in situations where diminished traction is desirable, or where the travel is so great as to render repairs of other pavements frequently necessary; in such cases—*as in the leading thoroughfares of a great city*—the original outlay becomes of less importance, when compared with the extreme durability, and other advantages of a suitable pavement of dressed stone.

Sir Henry Parnell mentions a pavement of this sort, which "had been laid down upwards of thirty years, and had cost very little in repairs." And the same author in 1833, mentions in relation to part of a great road leading into the city of London, which was paved with granite, under the direction of James Walker, C. E., President of the Institution of Civil Engineers, "that this paving has now been in use thirteen years, with almost the heaviest traffic out of London upon it, and, except the first year, when the contractor had to keep it up under his agreement, it has cost very little for repairs. It is now in excellent order, and the stones do not appear worn in the smallest degree."

The great durability, and the ease of traction, furnished by a dressed stone pavement, of suitably dimensioned stone, when it is properly laid, and properly founded, cannot, in point of fact, be disputed, and will justify its use, even as a matter of strict economy, in all streets that have to endure a crowded and heavy travel.

In the ordinary mode of paving with stone blocks, they are placed in courses perpendicular to the line of direction of the street, as has been done in this city, at the intersection of Sixth and Chesnut, and more recently in Chesnut, between Fourth and Fifth streets; but since upon this plan a number of joints lie parallel to the axis of the carriage-way, it has been found in practice, that the wheels of passing carriages, running in both directions along these joints, soon wear down, or round off, the arrises of the dressed stone blocks, so as gradually to form ruts, or holes between them, which in time render such pavements rough and uneven, and finally cause them to break up.

M. Le Large, a French writer in 1717, recognized this defect, and in a memoir upon the different modes of paving roads with squared stone, which may be found in the third volume of the "*Machines et Inventions approuvèes par L'Academie Royale des Sciences*," he suggested *a diagonal disposition* of the courses of stone, as a remedy therefor; and furnished two plans, or sketches, showing how the stones of a pavement might be so arranged in courses forming respectively, angles of 45°, and of 26½°, with the axis of the street.

The views of M. Le Large upon this point, were adopted and enforced by Mr. Edgeworth, in 1813, in his able essay on *Roads, &c.*, which was published at that time; but, notwithstanding the authority of this writer, and the approbation of the French Academy, *the diagonal system* of paving has not been as generally adopted as it deserves to be, though, in all probability, it will ultimately supersede the *rectangular mode.*

In the sixth volume of the Technical Repository, H. W. Revely, Civil Engineer, mentions that dressed stone pavements upon the diagonal system of large stone, *furrowed* transversely, were successfully employed long prior to 1824, "in the streets of Florence, Pisa, Leghorn, and other cities of Tuscany;" and he recommended similar pavements, laid in courses at an angle of 45° with the axis of the street, and forming salient angles in plan, at the middle of the carriage-way, as being suitable, in a high degree, for the pavements of the city of London.

We learn from Capt. Charles Mœring, an intelligent engineer officer in the Austrian service, now on a visit here, that in the great city of Vienna, the leading thoroughfares are now uniformly paved *in the diagonal manner,* which pavements succeed admirably, and which after sufficient experience under the heavy travel of that important place, have proved themselves to be so decidedly superior to the ancient pavements upon the rectangular system, that these latter are now relaid in the diagonal form, as fast as renewals become necessary.

If we leave the results of practice for a moment, and turn to abstract considerations, we shall find that they would lead us to form a favorable opinion of the diagonal mode of paving, for it is evident, that in a good dressed stone pavement with close joints, the most favorable direction in which a carriage wheel can act upon a joint, is perpendicular thereto, while the worst, is when the wheel runs along the length of the joint; hence in a pavement where part of the joints are parallel, and part of them perpendicular to the line of travel, unequal wear must inevitably result, and a roughness of surface ensue.

At the intersections of streets, where the travel upon both carriage ways, traverses the parallel joints, the wheels running in one street, will wear one set of joints, whilst in the line of the other carriage way, the rest of the joints will be injured, and, consequently, a pavement so situated, must wear rounding, and become irregular, in the course of time.

From the nature of the case, we should, therefore, conclude, that those pavements would wear the smoothest, and last the longest, which should be laid in such manner, *that carriages passing in both directions upon their surfaces, would cross all the joints of the paving at equal angles.*

This condition will be answered upon *the diagonal system,* even at the intersections of perpendicular streets, by causing the courses of paving to form angles of 45° with the axis of the carriage way.

Another strong argument in favor of a diagonal disposition of paving stone, may be found in the recent practice of distinguished engineers, upon many of the English railways.

The heavy stone blocks, square in plan, which carry the chairs of the edge rails, were formerly disposed with their sides parallel, and perpendicular to the track, occupying the same position as in a rectangular system of pavement; but now upon the London and Birmingham, and other great railways, the squared stone blocks are all placed *so that the line of the rails traverses a diagonal,* or are, in fact, disposed in relation to the travel, precisely as they would be in the diagonal system of paving: this change in the position of railway foundations, has resulted from a just conviction upon the part of the engineers, that a stone block disposed diagonally to the travel over it, *presents superior stability, both longitudinally, and laterally, since the lines of resistance in such case, become longer in both of these directions,* and this argument we need scarcely say applies with equal force to a stone block in a paved street.

A strong argument in favor of hexagonal blocks for paving streets, may be drawn from the foregoing considerations; since, if a hexagon

be placed horizontally in a pavement with two of its sides perpendicular to the axis of the street, the lines of travel will intersect the other four sides at angles of 30° in both directions; so that, in fact, they will cross two of the sides of the hexagon, in the most favorable direction possible, whilst all the other sides by their diagonal disposition, become more exempt from the injurious action of wheels along the joints, than would be the case with blocks of any other geometrical figure, *if set in regular transverse courses*, and would only be surpassed in this respect, by masses rectangular in plan, *and set diagonally at angles of forty-five degrees with the line of the street.*

We conclude then, *that a diagonal disposition is the best for dressed paving stone*, and having discussed the method of arrangement, we are now to consider the proper size for the stone blocks of a dressed pavement, and upon this point we find that considerable variation exists, both in successful practice, and in competent opinions.

Thus, in Naples, where stone pavements are laid upon the diagonal system, the blocks are closely jointed, are two feet square horizontally, and present a superficial area of four square feet each: in Pisa, Florence, and Leghorn, the stone blocks are also large, but in all these cases they become, by use, so dangerously smooth, as to require numerous furrows to be cut transversely to the line of travel, in order to secure a proper foothold for the passing horses; and in our own country, in the city of Boston, where a portion of Tremont street, in front of the Tremont house, is paved with granite blocks of eighteen inches square, showing two and a quarter superficial feet each, transverse furrows have also been found necessary.

These transverse furrows are laborious in execution, and also objectionable, on account of their roughness, and the noise they produce under vehicles—*fortunately they are not indispensable*—since in most of the cities of Europe, the same end has been answered by using smaller stone, and it is for this reason that in those cities, generally, the stone blocks are dressed into cubes of about two-thirds of a foot side, and showing, when set, only about one-half of a superficial foot, exposed to the travel.

Bryan Donkin, a Civil Engineer, in some interesting papers upon paving, written many years ago, proposed that dressed stone for the London pavements should be 5 inches broad, 7 to 8 inches long, and 10 to 13 inches in depth, vertically.

Sir Thomas Telford proposed for the pavements of the parish of St. George, in London, that the dimensions of the dressed paving stone should be as follows:

For streets of the—

1st. class, 10 ins. deep; 11 ins. to 13 ins. long; and 6 ins. to 7½ ins. broad.
2nd. " 9 " 9 " 12 " 5 " 7 "
3rd. " 7 or 8 " 7 " 11 " 4½ " 6 "

Sir Henry Parnell, like Telford, divided streets into three classes, proportionate to the travel over them; and he recommended the dimensions of the dressed stone to be as follows:

For streets of the—

1st. class, 10 ins. deep; 10 ins. to 15 long; and 6 ins. to 8 ins. broad.
2nd. " 8 " 8 " 12 " " 5 " 7 "
3rd. " 6 " 6 " 10 " " 4 " 6 "

The French engineers have been in the habit of forming their dressed paving—*like dice*—into rigid cubes of about 8 inches side; their example has been pretty generally followed upon the continent of Europe, and we may mention, that cubes of about this size, are employed in those streets of Vienna, which have been so successfully paved in the diagonal manner.

Although the best authorities differ in some degree, as to the most suitable dimensions of paving stone in a horizontal direction, *they all agree that a rigid uniformity of depth is indispensable;* and we may here remark, that in consequence of this maxim amongst others, having been overlooked, or neglected, in laying recently the dressed stone pavement in this city, in Chesnut street, between Fourth and Fifth, that piece of paving is neither a good specimen of dressed stone pavements, nor will its durability be such as might have been expected, if proper care in its construction, foundation, and materials, had been duly observed.

To satisfy the necessary conditions, it would seem that the showing surface of dressed stone paving, ought to bear to the horizontal dimensions of the hoofs of horses, a relation sufficiently close to secure a foothold, and avoid slipping; whilst, at the same time, the block should have sufficient bearing surface, should be incapable of tilting under a passing wheel, and should have an extent of base equal to that of the surface exposed to the travel.

The size established by the practice of continental Europe, may, perhaps, be regarded as a close approximation to the best dimensions possible, though slight departures from it horizontally, keeping the depth uniform, and maintaining regular courses, would not impair the character of the pavement, whilst the allowance of some little latitude in the superficial dimensions, would certainly be promotive of economy in getting out, and preparing the stone blocks.

It has sometimes been proposed to form the stone blocks into oblique prisms, as well as into some other shapes, but upon this point we have no hesitation in declaring the opinion, *that all the stone ought to be rectangular prisms*, as we can perceive no advantage in the figures of the other solids suggested, which would be at all commensurate with the trouble and expense of forming them.

In laying a dressed stone pavement, it is important that the joints should not be more open than those of masonry usually are, or, in other words, the stone blocks should not be allowed to set a wider joint, than from three-sixteenths to one quarter of an inch.

The advantage of a closely jointed pavement, over one that is not so, is well shown by the first fifty feet of the stone pavement recently laid in Chesnut street, east of Fifth, which portion certainly exhibits a decided superiority over the remaining pavement in that square, though its joints are wider than we should prescribe.

Whilst the noise of vehicles passing upon a well dressed, and closely

jointed pavement, would be trifling, and the ease of traction great, no serious apprehensions need be entertained, that pavements with joints of the size we recommend, will be too smooth, as we have no reason to believe that horses would often slip upon their surfaces, if stone of a suitable quality be used.

Sir Henry Parnell observes upon this point, "that it is supposed by some persons, that if the streets were paved in the way proposed, (that is to say with *dressed stone)* their surface would be too smooth for horses to go safely over them; but this supposition is not well founded, except when that kind of stone is used which becomes polished by wear."

"Scotch granite, and some other kinds of stone, do not become polished, and, therefore, pavements made with them, will never have so smooth a surface as to be unfit for horses. A horse properly shod will seldom slip on a pavement, or fall, unless when thrown down by being turned too short, or other careless management."

In support of these observations, it may be remarked, that on the well dressed pavements of Vienna, and other European cities, a dangerous slipping of horses occurs so rarely, as not to form a valid practical objection; though it must be admitted, that in the nature of things, a certain degree of slipperiness, is inseparable from the smoothness of all good pavements.

Finally, with regard to pavements of dressed stone, we have, in substance, concluded—that they ought to be laid upon a foundation formed by another pavement, as is the custom in Paris—that the stone blocks should be disposed diagonally at angles of 45° with the axis of the street—that these blocks should approximate closely to a cube of eight inches side, or be parallelopipeds nearly cubical—that none of the joints between the blocks, when set, should be allowed to exceed three-sixteenths, or a quarter of an inch in width—and that the depths of all the blocks should be strictly uniform.

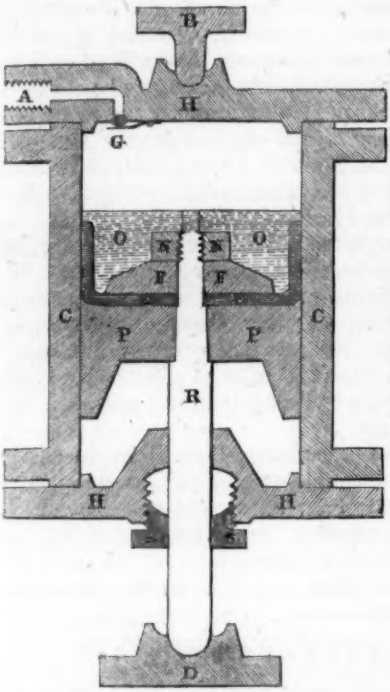
(To be continued.)

Report on Bisssell's Pneumatic Car or Carriage Spring.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination, the Pneumatic Car or Carriage Spring, invented by LEVI BISSELL, of Newark, New Jersey, REPORT:

That this spring is constructed with a cylinder closed at both ends, and charged with condensed air, which is acted upon by a piston. The cylinder is charged by a force-pump through a small opening in the upper head, which is closed by a valve opening inwards. The piston is of solid cast-iron, with a stem, or rod, passing through a stuffing-box, in the lower head, into a seat, or socket, on which the spring acts. The packing of the piston consists of a leather cup of the exact diameter of the cylinder, and of about two inches in depth, resting on its upper surface, and secured to it by a circular cast-iron plate, and a nut screwed on the upper end of the piston rod. This

cup is partly filled with ground white lead, upon which is placed a quantity of oil—say two inches in depth—to make the piston air-tight. The weight supported by the spring rests on the centre of the upper head of the cylinder. The spring submitted for examination, was one of four designed to support an eight-wheeled passenger car, of about ten tons weight, including its load. The cylinder was of cast-iron, six inches calibre, ten inches long, and three-fourths of an inch in thickness.



A, opening to attach air-pumps.
B, post sustaining load.
C, cylinder.
D, seat for piston-rod.
E, leather cup-packing.
F, cast-iron follower.
G, valve and valve-spring.
H, H, cylinder heads.
N, nut to secure packing.
O, oil and white lead.
P, piston.
R, piston-rod.
S, stuffing-box.

Springs of this description, made by Mr. Bissell, have been in use on the railroad cars running between Philadelphia and New York, for more than one year, and, the committee understand, have given entire satisfaction to the officers of the railroad company, and the traveling public. The difficulty originally and generally anticipated in their use, viz.,—the escape of the air from the cylinder, under a pressure of from two to four hundred pounds per inch, has not been realized—on the contrary, some of those in daily use have retained the air for upwards of five months, and remain in perfect order.

The arrangement of this spring is, undoubtedly, ingenious, but the committee feel bound to state, that it cannot be regarded as a novel invention. It is almost identically the same as the *Pneumatic Railroad Carriage Spring, Railway Buffer, and Elastic Drag*, in-

vented by Mr. Burstall, and patented in 1839;—a description and drawing of which can be found in the London Mechanic's Magazine, vol. xxxi., p. 423. Mr. Burstall employed a cylinder, inclosing condensed air in a flexible sack, which was acted on by a piston in the same manner as that of Mr. Bissell. Mr. Stephenson, the celebrated English engineer, also employed cylinders with solid pistons, which acted against the water and steam, on his locomotive steam engine boilers *as springs*, as far back as 1814; descriptions and drawings of which can be seen in almost every work published upon railroads since that date. Mr. Robert Bowman, of Scotland, also invented a similar contrivance, for the purpose of stopping, or checking, chain cables of vessels, in 1825. It consisted of two cylinders fixed parallel to each other on the deck of the vessel, that were charged with condensed air by a force-pump, and were acted upon as a spring by pistons;—a description and drawing of which can be found in Newton's Journal of Arts and Sciences, vol. ii., p. 179. Mr. Robert Mallet, of England, also patented a similar contrivance in 1836, which he describes in vol. xxxvi. of the London Mechanics Magazine, p. 212. In his description of his improvement, he speaks of having used *a leather cupped packing, containing oil, or water, to make it air tight.* Mr. Mallet preferred water to oil, because it would not penetrate the leather under pressure, as readily as oil. Mr. Bissell prevents it, by a mixture of white lead with the oil. See also a description of Church's Air Spring, in Newton's (London) Journal of Arts and Sciences, vol. ii., conjoined series, p. 97 and 98, which is [identical] with Mr. Bissell's spring in almost all its details.

The committee award much credit to Mr. Bissell, for the energy and patience with which he has introduced, and put in use in this country, a valuable, though, not a novel, improvement. Mr. Bissel obtained a patent for his springs, which is dated the 11th of October, 1841.

By order of the Committee,

October 13*th*, 1842. WILLIAM HAMILTON, Actuary.

Civil Engineering.

Mr. Vignoles' Lectures on Civil Engineering, at the London University College.

[Continued from Page 80.]

LECTURE XIII.

In continuation of the observations on *Railway Estimates*, which had been commenced in the last lecture, Mr. Vignoles observed that, having therein gone fully into the items of *construction* of railways, he had only glanced at the very necessary provision to be made for the efficient *working* of them—viz., the *Station and Carrying-establishment*, upon which he would say a few more words, for it was mostly under this head that the chief causes—or, rather, the chief excuses—for extra expenditure, or excess of estimates, had arisen. Properly speaking, this item, so costly, and yet so indispensable, should be taken as falling on a railway company, not as proprietors of the road, but as carriers—the distinction being, that if the railway was

let on lease, as canals have been, or if every body could carry on the railways, as they do on the canals—if, in short, public safety and public convenience, and generally necessary arrangements, did not make it imperative, or, at least, highly desirable, that the railway companies should be carriers (of passengers, at all events,) the expense of stations, and carrying establishment would not fall on them, though they must still be incurred by some parties, before the railway can be brought into profitable operation; nevertheless, the public, who are to use, and be benefited by the road, having, after all, to pay in one shape or another, are greatly interested in a proper expenditure, any excess of which is sure to be felt in increased charges, or in diminished accommodation, until the grievous expenditure of a rival line is introduced. In analyzing the cost of *Stations*, it is obvious that the land always forms a prominent item, for, being near towns and populous places, it is to be bought by the yard, and not by the acre—building land, villa land, &c. &c., instead of mere fields. Hence, it will not be surprising, if it is found that the cost of the land, for the stations only, on many of the great lines, has amounted to as much as one-third of the whole cost of land for the railway. The *buildings* erected at stations may be divided into three classes—those for the accommodation of the passenger traffic—those for the goods, minerals, &c.—and those for the repair and maintenance of the engines, carriages, &c. At principal towns, therefore, large and distinct establishments must be erected; and, on long lines, a principal central depot for the engines, is often required in addition. At the minor and road stations, the whole may be grouped together under one roof. In no department of expenditure, have so many differences, and so much useless extravagance in construction and arrangement, been displayed, as in the buildings at stations; and hundreds of thousands of pounds have been absolutely thrown away, from want of sufficient forethought and consideration, and by erecting enormous masses of buildings, either at the wrong places, or in an injudicious manner. It was better to wait until the character of the traffic was ascertained, before making such expensive permanent establishments, and then increase the accommodation by degrees. As an example of a moderate expenditure under this head, Mr. Vignoles mentioned some particular instances, and went somewhat into detail. At the terminus of a railway in a manufacturing town, with 80,000 inhabitants, there had been an expenditure of £9,500, for the passenger buildings, sheds, &c. &c.; £5,500, for goods' warehouses; about £2,000, for the mineral traffic; and about £3,000, for fixtures, turnplates, &c.—say, in all, about £20,000, exclusive of the land, which had amounted to a very large sum, upwards of £13,000, including a good deal of spare space, existing buildings, &c. &c. At a smaller town on the line, but with some extent of goods traffic, the cost for passenger buildings, sheds, &c., was £2,500; for merchandize accommodation, £3,500; turnplates, fixtures, tools, &c. &c., £1,000; land about £3,000. On the same railway, the cost of six or seven various minor road stations, including water tanks, coke, and engine sheds, tools, &c., was £3,500; land about £1,500; sundries on the whole line about £1,000—being a gross expenditure of £50,000 on station, land, and buildings, for a line of about twenty-two

miles, which is at the rate of £2,273 per mile; and the corresponding carrying establishment of engines, tenders, &c. (for passenger traffic only), was about £19,000; for passenger carriages of three classes, horse-boxes, trucks, &c. &c., about £13,000, (the wagons for merchandize, coal, &c., as well as the engines, &c., being provided by carriers on the line, who provided their own carrying stock); and the necessary buildings for repair, and maintenance of engines, carriages, &c., with tools, fixtures, &c. &c., about £12,000—making a gross cost of £44,000, or £2,000 per mile. The whole of this concern having been arranged with the strictest regard to economy, may be taken as a fair average, and it will be safe to say, that £4,000 per mile, for an effective carrying establishment, with the necessary stations, is a moderate sum. For lines of less traffic, if of considerable extent—as, for instance, say for some of the long lines from the present railway termini in the north of England, to either of the principal towns in Scotland, a smaller amount might be sufficient; but Mr. Vignoles considered that it would be unwise to estimate a smaller expenditure than that of £3,000 per mile, for *Stations and Carrying-establishment*, on a line to be worked by locomotive engines, and it would be much safer to take £4,000; on either of these sums, £1,500 per mile for the locomotive stock and buildings must always be estimated, and about £500 per mile for the carriage department—leaving from £1,000 to £2,000 per mile for the stations, according to the extent of accommodation; keeping the instances of the extraordinary outlay on some of the principal railway lines as examples to be avoided, and not to be imitated, or referred to, as necessary.

Under the last head of *Management*, came all the various and miscellaneous items of expenditure, between the first concoction of the project, to the closing of the capital account. The preliminary expenses of examining the ground, leveling, surveying, maps, &c., and all the formalities in the engineer's department, to enable application to be made to Parliament; the ascertainment of the traffic, revenue, traveling, and other expenses of various kinds, &c. &c., generally undertaken by the secretary; the valuation of land, &c., by the surveyor; the collection of the names of the owners and occupiers, notices to them, applications for their assents, &c., and the management of the bill throughout all its stages, falling to the charge of the solicitor. All these must be incurred before a spade was put into the ground, and had heretofore varied from £500 to £1000 per mile, according to the facilities afforded, the opposition encountered, the length of the line, &c. In future estimates, it was to be hoped this item might fairly be put, as not exceeding the smaller of these sums. Then came the setting out of the line, the detailed levels and surveys, and all the office work of the engineer, until the works are put into the hands of the contractor. The minute valuations of the property to be taken, and the juries, references, conveyancing, stamps, and all the various legal steps, until the company are put into full possession. Then the office establishment for regulating all the financial and ministerial affairs, and the temporary arrangements, police, lawsuits, and legal and illegal charges of all kinds, taxes and rates, interest and commission to agents and brokers, traveling expenses, salaries, and

a great variety of disbursements of a miscellaneous kind, which, in the aggregate, amount to a large sum. The whole of the outlay thus coming under the head of *Management*, has varied from 5 to 10 per cent. on the gross cost of the railways hitherto executed, according to their extent, and the amount of capital embarked, and especially according to the degree of vigilance exercised to keep down expenses, which depends chiefly on the director, or secretary, or under whatever name the acting manager of the company may superintend. Judging from the examples past, and the deep impression which has been made on the public mind, of the necessity of economy in every department, Mr. Vignoles thought 5 per cent. might be estimated hereafter, unless the lines were very short, and the capital small.

In recapitulation, the Professor observed, that the young engineer should always keep in view, for his estimates, the preceding great divisions of the cost—viz., *land*, including the damages, and fencing —*earthwork*—*works of art* (bridging and masonry, &c.)—*upper works* (the permanent railway proper)—*stations and carrying establishment*—*management*—and having, in his first estimates, allowed amply for each of those items under their several heads, he should add at least 10 per cent. for unforeseen contingencies. Some of the preceding items would be common to almost all railways, and others, of course, would vary greatly, according to local circumstances, chiefly regulated by the amount of earthwork; for, as that is heavy, so the works of art become costly, since the works of art are merely to restore the existing communications of the country, and the natural, or artificial, water-courses, and drainage to their state before disturbed, or as near as may be, and that to an extent in exact proportion to the civilization, and improvement of the country, to enforce all which stringent clauses are inserted in the Acts of Parliament, and plenty of persons are always on the watch to enforce them. Mr. Vignoles observed, that the land, leveling of the ground, and restoring of communications, might, on the average, including contingencies, extra land, &c., be taken as forming about 50 per cent. on the total outlay of railways hitherto executed. But, referring to the items the Professor had gone over in detail in previous lectures, it appeared that, when proper economy and circumspection were used, the necessary cost of the railway proper—that is, the necessary quantity of land for the road only, a good substantial set of upper works for a double way, and a complete and effective carrying establishment—might, and had been, obtained for £10,000 per mile. All beyond is expenditure to obtain gradients, more, or less, perfect, and Mr. Vignoles thought that the great error all engineers had hitherto committed, the cardinal mistake —of which he himself was far from guiltless—was, seeking to make railways, intended, as they were, chiefly for passengers, *too perfect*—that is, of cutting down hills, and filling up valleys to too great an extent, on the erroneous supposition that the engines were always to carry *maximum* loads, which was very seldom the case, and never would be so on lines at a distance from the metropolis, particularly such as the lines into Scotland, previously mentioned. In short, the Professor insisted that the engineer should, in such instances, and for

the cross railways, which he yet hoped might be introduced, make the gradients and curves much less theoretically perfect; and that the amount of expenditure, beyond the above stated necessary one of £10,000 per mile, should be reduced to the very *minimum;* and he considered that henceforth an average of £15,000, or £16,000 per mile, and a *maximum* of £20,000, or, in very extraordinary cases, indeed, of £25,000, should be looked to for the construction of double lines of railway in any country, but that in most cases, of light traffic, and consequent adaptation of gradients, for single lines, a sum of from £7000 to £12,000 per mile. would be the limit of total expenditure. Mr. Vignoles concluded by observing, that the preceding abstracts were deduced from very detailed accounts, which had been arranged on a uniform system, and kept from the very commencement of each undertaking, so as to be available at any time during the progress of the works, to show the exact state of the expenditure; and had been finally worked out to the nearest thousand pounds, as above. And the Professor expressed his great hope and expectation that this example would be followed, and that similar accounts would shortly be forthcoming, of the corresponding items of cost on all the principal railways in this and in other countries, more especially where complaints of improper excess of expenditure over estimates (well or ill-founded) had been charged, for the publication of such accounts—and the more in detail the better—would be the most complete defence of the directors, and the most satisfactory explanation from the engineer, and alike valuable, as statistical information to the country—as salutary guidance to the capitalist and speculator—and as valuable information and warning to the old, as well as to the young practitioner.

The preceding is a very brief outline of this interesting lecture, and the following, we believe, is a correct abstract of the cost of the two railways quoted by Mr. Vignoles.

COMPARATIVE ABSTRACT

Of the Cost of two Principal Lines of Railway, under the general heads of Expenditure, as deduced from the very latest accounts of Actual Expenditure, brought out to the nearest round numbers:

MIDLAND COUNTIES RAILWAY. [57¼ MILES.]				
Heads of Expenditure.	— — —	Pr. ct. whole cost,	C't. pr. Mile £	Total Cost. £
Railway land, and damages,	(790 acres)	12	3463	200,000
Fencing, gates, roads, &c.,		3½	1004	58,000
Earth work,	(5,700,000 cubic yards)	18½	5455	315,000
Works of art, of all kinds,	[tons]	15	4364	252,000
Iron rails and chairs,	Upper Works £215,000—(17,670)	23	6822	394,000
All other materials, and labor,	Works 179,000			
Station land, and damages,	Stations and carrying establishment. £ 51,000			
Buildings, fittings-up, &c.,	168,000	21	6147	355,000
Engine, &c. stock,	75,000			
Carriage, &c. stock,	61,000			
Management, law, interest, &c		7	2182	126,000
Totals,	— — —	100	29,437	1,700,000

NORTH UNION RAILWAY.
[25 MILES.]

Heads of Expenditure.	— — —	Pr. ct. whole cost	C't. pr. Mile. £	Total Cost. £
Railway land, and damages,	(320 acres)	8	2000	50,000
Fencing, gates, roads, &c,		3½	800	20,000
Earth work,	(2,900,000 cubic yards)	20½	5000	125,000
Works of art, of all kinds,		20½	5000	125,000
Iron rails and chairs,	Upper works £68,000 (6885 tons.)	21	5200	130,000
All other materials, and labor,	62,000			
Station land, and damages,	£18,000			
Buildings, fittings-up, &c.,	Stations and carrying establishment. 48,000	16½	4000	100,000
Engine, &c. stock,	20,000			
Carriage, &c. stock,	14,000			
Management, law, interest, &c.		10	2400	60,000
Totals,	— — —	100	24,400	610,000

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

American Steam Excavator of Otis, or the Yankee Geologist.

Having availed himself of a recent invitation from Messrs. Eastwick & Harrison, Engineers and Machinists of this place, to view *three* well constructed steam excavators, which these gentlemen have just completed for the Emperor of Russia, and are about to ship for that country, to be there employed upon the extensive railways about to be commenced; the writer collected a little information relative to them, which may, possibly, interest some of the readers of this journal.

These steam excavators, as devised by the late ingenious Mr. Otis, are really high efforts of inventive talent, and will do credit to American ingenuity wherever they are seen and used.

But *seven* of these machines have yet been built, the whole of which, excepting the first, having been made by Messrs. Eastwick & Harrison; the first was partially completed at various workshops, under the direction of the inventor, Mr. Otis, in person; but finding some diffiulty in organizing and fitting up so complicated a machine, by this method of proceding, he fortunately placed it in the hands of Messrs. Eastwick & Harrison, who skilfully perfected the details, and gave such good proportions to the several parts, that all the machines constructed, including the experimental one, have proved, in practice, to be completely successful, though it has been deemed advisable to give augmented strength to those recently built.

The present price of these machines in Philadelphia, is $6,500, but in consequence of the patterns being now on hand, and of the complete system, introduced by these excellent mechanics, into the manufacture of this new machine, it seems probable that Messrs. Eastwick & Harrison may, hereafter, be able to furnish them even at lower rates.

The high pressure steam engine, which operates each of the excavators viewed by the writer, has a single cylinder, of 9 inches in

diameter, and 1 foot stroke, the speed of the piston being usually about 200 feet per minute, when the pressure on the safety-valve is 100 lbs. per square inch; and, consequently, in the ordinary mode of computing small high pressure engines, it will realize *about fifteen horses' power.*

From the large amount of work which has already been done by some of these machines, in an active service of several years, there seems to be but little doubt, that one of them, in a common working day, *can dig and load from* 800 *to* 1200 *cubic yards of average earth.*

The scoop will contain about a cubic yard of earth measured in the cut, and a common day's work is 1000 full dips of the scoop, but 1200, or 1300, have frequently been made; we may, therefore, from our present information, set down as a certain average work, 1000 *cubic yards excavated, and loaded upon cars per day.*

It will be borne in mind, that the "*yankee geologist*" merely does the digging and loading, or the getting and filling, *the transportation, dumping, trimming, &c.*, remaining the same as though the cars had been loaded by the labor of men, in the usual manner.

In heavy excavations of common earth, where a large number of men have been employed, the writer has often observed, that the work of hands rarely averaged more than 12½ cubic yards, loaded into a cart per day, per man, the earth being previously *loosened* by the pick, or plough.

Now, taking the wages of men at *one dollar* per day, including all charges, and putting the *loosening* at the moderate estimate of one cent per cubic yard, the actual cost of digging and loading, in an average case of heavy earthwork, would be *about nine cents per cubic yard.*

We will now, from the best information before us, frame an estimate of the probable cost of excavating and loading ordinary earth in heavy cuts, by the aid of the "*yankee geologist.*"

Probable Annual Charges.

Interest on cost at 6 per cent. on $6,500,	$ 390
Renewals, wear and tear, say 25 per cent.,	1,625
One cord of wood per day, at $4, for 300 days,	1,200
Oil and packing, $1.50 per day × 300 days,	450
Two machine tenders, at $1.50 per day, for 300 days,	900
Eight car tenders, at $1 per day, for 300 days,	2,400
One overseer, for 300 days, at $2 per day,	600
Total expenses per annum, say,	$ 7,565

Now, in 300 working days, this machine would, from the data given, excavate and fill into cars, about 300,000 yards; and hence, it would appear, that where it is able to work 300 days in a year, this machine would dig and load ordinary earth, at the extraordinary low rate of two and a half cents—or, allowing for contingencies, say *three cents per cubic yard;* which is only about one-third of what it would cost by manual labor.

Such is the surprising result, to which the writer has been led by the information laid before him, by Messrs. Eastwick & Harrison, and which, if it be even approximated to, in the general continuous working of these steam excavators, *will, inevitably, enable them to banish manual labor from the digging and loading, in all heavy earthworks.* M.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

Mr. Mallett's Close Breast for an Overshot Water-Wheel, not New.

In the July number of the Journal of the Franklin Institute, the writer has observed an abstract of some experiments made by Mr. Mallett, to prove that an advantage of from "8 *to* 11 *per cent.*" may be obtained by the use of a close breast to confine the water upon the lower quadrant of an overshot water-wheel.

These experiments seem to have been announced to the Institution of Civil Engineers, by Mr. Mallett, and discussed by that intelligent body, as though the application of a close breast, in the manner referred to—or, at the least, the valuation of its advantages—had been both new and original with Mr. Mallett; and though we will not pretend to say that the latter was not the case, we cannot repress a feeling of surprise, that such a well read man should have overlooked the fact, that the Franklin Institute, upon a much superior scale to his, had, long since, made with full sized water-wheels, all the experiments necessary to settle conclusively, every point relative to "*the coefficient of laboring force in overshot water-wheels, &c.,*" which he has attempted to illustrate, by his little tin models of 25 and 33 inches in diameter.

It was for the very purpose of obviating the just objections urged against the results obtained by Smeaton, Bossut, Banks, and others, from *little models* of water-wheels, that the extensive experiments of the Franklin Institute were undertaken.

In the face of these, and of that able series of trials made by Morin, on water-wheels actually driving heavy works in France, are we now to return again to the imperfect conclusions derived from insignificant models? We anticipate the answer of well trained mechanics every where to be NO!

It would have been singular, indeed, if an experiment so obvious, as that of applying a close breast to the lower acting quadrant of an overshot water-wheel, should have escaped the attention of the committee of the Franklin Institute; and, accordingly, we find their conclusions upon this point, recorded in vol. i., 3rd. series, of this journal, p. 368, where they clearly show, with regard to the "*use of a close breast with an overshot water-wheel,*" that the ratio of effect to power, "appears to be in favor of the use of the breast, in the proportion of .751 to .702, or of 1.07 to 1.00, under the average of heads from 0.25 to 3.75 feet, and of head and fall from 10.5 to 14.0 feet."

In conclusion, we recommend these prior experiments to Mr. Mallett's consideration, as furnishing a much safer basis for practical operations, than can possibly be the case with his own. M.

On the causes of the unexpected breakage of the Journals of Railway Axles; and on the mean of preventing such accidents by observing the Law of Continuity in their construction. By WILLIAM JOHN MACQUORN RANKINE, Assoc. Inst. C. E.

The paper commences by stating that the unexpected fracture of originally good axles, after running for several years, without any appearance of unsoundness, must be caused by a gradual deterioration in the course of working; that with respect to the nature, and cause of this deterioration, nothing but hypotheses have hitherto been given: the most accepted reason being, that the fibrous texture of malleable iron assumes gradually a crystallized structure, which being weaker in a longitudinal direction, gives way under a shock, that the same iron, when in its fibrous state, would have sustained without injury.

The author contends that it is difficult to prove that an axle which, when broken, shall be found of a crystalized texture, may not have been so originally at the point of fracture, although at other parts the texture may have been fibrous.

He then proceeds to show that a gradual deterioration takes place in axles without their losing their fibrous texture, and that it does not arise from the cause to which it is usually attributed.

From among a large collection of faggoted axles which had broken after running between two and four years, five specimens were selected, of which drawings are given, representing the exact appearance of the metal at the point of fracture, which in each case occurred at the re-entering angle, where the journal joined the body. The fractures appear to have commenced with a smooth, regularly formed, minute fissure, extending all around the neck of the journal, and penetrating, on an average, to a depth of half an inch. They would appear to have gradually penetrated from the surface towards the centre, in such a manner that the broken end of the journal was convex, and necessarily the body of the axle was concave, until the thickness of sound iron in the centre became insufficient to support the shocks to which it was exposed.

In all the specimens, the iron remained fibrous; proving that no material change had taken place in its structure.

The author then proceeds to argue, that the breaking of these axles was owing to a tendency of the abrupt change in thickness, where the journal met the shoulder, to increase the effect of shocks at that point; that owing to the method of manufacture, the fibres did not follow the surface of the shoulder, but that they penetrated straight into the body of the axle; that the power of a fibre to resist a shock being in the compound ratio of its strength and extensibility, that portion of it which is within the mass of the body of the axle, will have less elasticity than that in the journal, and it is probable that the fibres give way at the shoulder, on account of their elastic play being suddenly arrested at that point. This, he contends, would account for the direction of the fissure being inward towards the body of the axle, so that the surface of the fracture was always convex in that direction.

It is, therefore, proposed in manufacturing axles, to form the journals with a large curve in the shoulder, before going to the lathe, so that the fibre shall be continuous throughout; the increased action at the shoulder, would thus be made efficient in adding strength to the fibres without impeding their elasticity. Several axles having one end manufactured in this manner, and the other by the ordinary method, were broken: the former resisted from five to eight blows of a hammer, while the latter were invariably broken by one blow.

The vibratory action to which axles are subjected is then considered, and it is contended, that at the place where there is an abrupt change in the extent of the oscillations of the molecules of the iron, these molecules must necessarily be more easily torn asunder; and that in the improved form of journals, as the power of resisting shocks is increased by the continuity of the superficial fibres, so is the destructive action of the vibratory movement prevented by the continuity of form.

The paper is illustrated by five drawings, showing the section of the journals of broken axles, and their appearance at the moment of fracture.

Mr. York agreed with Mr. Rankine in several points, and stated, that since the last meeting, he had made a series of experiments, which confirmed his opinion relative to the vibration in solid railway axles being arrested, when the wheels were keyed on tight. In all such cases, where the vibration was checked, fracture would, he contended, be more likely to ensue, but with hollow axles, there was very little difference of sound when struck, and no diminution of strength, after keying on the wheels; this he attributed to the regular distribution of the molecules in the metal of the hollow cylinder.

Mr. Parkes coincided with Mr. York's opinion, and he believed that hollow axles would eventually supersede solid ones, particularly if they had sufficient rigidity for resisting flexure. Their faculty of transmitting vibration more readily was in their favor; it was well understood, that in pieces of ordnance, and musket-barrels, great regularity of proportion in the metal was requisite, in order to insure the equal transmission of the vibration, caused by the sudden expansion of the metal at the moment of the explosion, and unless the vibration was regular, the barrel would burst, or the ball would not be correctly delivered.

Mr. Greener, of Newcastle, among other experiments, turned the outside of a musket-barrel to a correct taper, and fixed tight upon it at given intervals, several rings of lead, 2 inches in thickness; on firing a charge of 4 drachms of powder, he found that all the rings were loosened, and had all expanded regularly in their diameter.

It was a well known fact, that cannon seldom, or never, burst from continuous firing; such accidents, unless they arose from peculiar circumstances, generally occurred in consequence either of inequality in the nature of the metal, or irregularity in its distribution; to the latter cause must be attributed the bursting of the "Mortier monstre," before Antwerp, and of a large gun which was proved at Deal, some time since; this latter gun burst at the third discharge, after delivering the ball better than on either of the previous discharges; it was

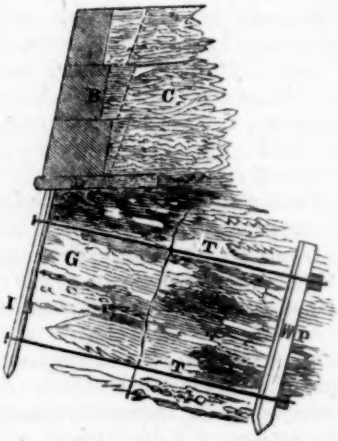
evident that the fracture did not occur under the explosion of the powder, but on the re-entering of the air into the mouth of the gun after the discharge, and also because the thickness of metal was not well proportioned, whereby the vibration was unduly checked, the cohesion of the molecules of the metal was destroyed, and the gun fell into several pieces, without any of them being projected, as they would have been by the usual effect of an explosive force.

The most practical millwrights were well aware of the superiority of hollow shafts, and they were frequently used, as they were more easily kept cool than solid ones, especially at high velocities, when shafts were peculiarly liable to injury from percussive force, or from a series of recurring vibrations.

Lond. Mechanics' Mag.

Greenwich Pier.

We abstained last month from giving any account of the failure of this pier, which took place on 16th of May last, as we had not then an opportunity of personally inspecting it, or of ascertaining its construction; we have since been favored by our valuable correspondent, O. T., with the following observations, and sketch of the pier. He observes, "the failure of Greenwich pier is not a matter of surprise to parties who understand the practical construction of such works. The immediate cause of the failure was dredging in front of the piles, after the contractor had left the works, and the arrangement of the piles being faulty, as regards construction; the upper part is composed of brickwork in cement B, 18 feet high, and 14 inches thick at top, capped with granite 1 foot thick, backed with concrete, C, and standing upon a foundation of Yorkshire stone landings, L, laid on a small quantity of concrete, with a substratum of foul gravel, G. The landing, in front, rests on a row of cast iron piles, I, P, 25 feet long, and 5 feet apart, grooved to admit between them three cast iron plates, each 6 feet in height, these iron piles were fastened by four, or two, pair of wrought iron land ties, T, 2 inches square, to wooden piles, W, P, 18 feet long, and 12 inches square, driven in land at a distance of 25½ ft. from the front, and 5 ft. apart." The high water mark is about 4 feet from the top, and low water mark 22 feet below, or about 7 feet below the stone landing. From inquiry, we rather suspect the lower ties, as shown in the sketch, were not fixed, nor do we see how they could



be, as they are shown considerably below low water mark. The superincumbent weight of the brickwork appears to have forced out the upper part of the iron piles to a considerable distance, and caused the brickwork above to slip down, and force out the iron plate; but, it is very difficult to say whether this is the real cause of the failure, for, until the ruins are cleared away, nothing positive can be stated.

Civ. Eng. & Arch. Journ.

Railway Axles.

A paper by Captain Handcock was read May 16th, 1843, describing a railway axle invented by him, which had been used for nine months on the Southampton Railway. The alterations consisted in making the journals of a conical form at the shoulder end, and at the outer end, a similar conical collar slides upon the journal, and can be forced forward by a screw collar at the extremity; the brasses are also conical at the entrances, following the parallel form of the journal, and meet in the centre within half an inch; they can revolve in the bored cast iron boxes when the friction upon the axle becomes excessive. It has been found that this form prevents the usual oscillation of the carriages, because, if the brasses wear, the conical collar is screwed up, and the lateral motion ceases; the wear and tear is diminished, and the saving of oil is very great: it was stated that one pint of oil had sufficed to lubricate all the axle-bearings of a six-wheeled engine, and a four-wheeled tender whilst running 924 miles; and that there was not any tendency to heat.—*Trans. Civ. Eng.*

Lond. Athenæum.

Unburnt Bricks from the Pyramids of Daskmoor, Egypt.

From the description by Mr. Perring, who brought them to England, it appeared that they were made from the alluvial soil of the Valley of the Nile, mixed up with chopped straw; that they were made with cavities in the sides like the modern bricks, and that the interior of the Pyramids was formed of *arches*, the bricks composing them, being either packed behind with pieces of flat pottery, or cut away to radiate equally from the centre. There existed at Thebes some extensive ranges of arches, of about twelve feet span, the bricks of which they were built bearing the name of Sesostris, and, consequently, they must have stood uninjured upwards of 3180 years; the arches were turned in concentric half-brick rings. Ibid.

Captain Norton's Lotus Floating Breakwater.

On a lake or pond where the lotus grows, Captain Norton had observed, that when there was a strong breeze, and waves on one side, on the other the water was comparatively smooth, resulting from the wind having no hold on the broad expanse of lotus leaves. He had also observed, after a storm at sea, the solid timbers of a wrecked vessel splintered in pieces by being driven against the shore, while a

wicker basket escaped uninjured. These two results suggested the idea of constructing a floating breakwater of oziers, according to the singularly ingenious model in the Polytechnic Institution, the expense of which would be trifling compared with others.

Polytechnic Journal.

Architecture.

The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds. By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 98.)

II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

The *buildings* required in cemeteries may next occupy our attention. A chapel, or chapels, are generally required, because some persons prefer the burial service read under cover, or this may be rendered necessary by the state of the weather. The size of a chapel, therefore, should be such as to afford seats for the ordinary number of attendants at a funeral, with an open area in the centre, of sufficient diameter to hold two or more coffins on biers; and, as it is a general custom in Christendom to carry a corpse with the feet before, the body being brought in, and set down on the bier in that position, is, after the service is over, taken up by men and turned completely round, so that the feet may be in advance before it is taken out of the chapel. In addition, therefore, to the space necessary for holding the bier and the coffin, there must be room for turning the latter completely round, either while on the bier, which has long handles for that purpose, or on men's shoulders. A circle 10 or 12 feet in diameter, or a square that would contain such a circle, will afford ample space for these purposes, and the remainder of the chapel may be occupied with the pulpit, desk, seats, &c.

In the chapels of some of the new London cemeteries, instead of biers for the coffins, there is a table, the top of which has one or two spaces, each of the width of a coffin, filled in with rollers, and the entire top of the table turns on a pivot. The coffin, or coffins, when brought in, are put on the table, by sliding them on the rollers; and, after the service has been performed, the table is turned round on its pivot, when the coffins being thus placed in the right position for going out, are carried away by the bearers. The rollers facilitate the sliding on, and drawing off, of the coffins, and the turning of the table, by means of the pivot, saves the most difficult and awkward portion of the labor performed by the bearers, who, when not much accustomed to it, are apt to stumble, and create alarm in the mourners lest the coffin should fall. When a bier-table of this kind is used, the area left for it need not exceed 8 ft. in diameter, which will thus save 4 ft. in the entire length, and the same in the breadth, of the chapel.

A very convenient apparatus of this kind has been put up at the Kensal Green Cemetery. In the body of the chapel is a bier, in the form of an altar, about 8 ft. long, 4 ft. broad, and 4 ft. high, hung round with black velvet. The upper surface of this altar-like structure consists of a top for holding one or two coffins; and, to facilitate the putting on and taking off of these, this plate, or top, is furnished with rollers. After the desk service has been read, the top containing the coffin, or coffins, can be turned slowly round by machinery, operated on by a small movable winch handle on one side, which is done after the service has been read, when the interment is to take place in the open ground, or in the catacombs at a distance from the chapel; but, when the coffin is to be removed to the vaults under the chapel, there is machinery below, worked by a man there, on a signal being given, by ringing a small bell, by which the entire bier, and the coffin, or coffins, which may be on it, are slowly lowered into a central area in the vault beneath. The mourners having descended by a staircase much too small for a chapel so magnificent in other respects, the coffins are carried from this area to the vaults, which radiate from it in four directions, and occupy nearly an acre of ground. The machinery by which the bier is lowered, consists of two vertical male screws, worked by two female screws, or nuts, which are moved by means of two beveled wheels set in motion by a man turning a windlass handle. This machine, while it lowers the bier through the floor, moves at the same time two horizontal shutters, which gradually close the opening in the floor, as the coffin descends from the view of the spectators in the chapel; while, by the time they have arrived in the area below, the bier is already at the bottom, with the coffin on it, ready to be removed to the vault. The great advantage of using a screw movement for the descent of the bier, is, that the motion can never be otherwise than slow and solemn, and that it cannot run down in case of the handle being set at liberty. This admirable contrivance was invented and executed by Mr. Smith, Engineer, Princes Street, Leicester Square, the patentee of an excellent window shutter, and of several other inventions noticed in our *Encyclop. of Cott. Architecture.* The cost was about 400*l.* In the Norwood Cemetery the same object is effected by means of Bramah's hydraulic press, which raises and lowers the bier with the slightest possible noise, and with a degree of steadiness which cannot be equalled by any other machine. The cost is about 200*l.* There is one drawback, however, to this machine, which is, that during very severe frosts the water is liable to freeze; but this may be guarded against by shutting all the outside doors of the vaults, and by the use of stoves. In ordinary winters, however, the latter are unnecessary. This machine was put up by Messrs. Bramah, Prestage, and Ball.

The number of sittings need seldom exceed fifty, at least in the neighborhood of London, as it rarely happens that more than a fourth of that number attend a funeral. Whatever be the architectural style of the chapel, it ought to contain a bell, the ringing of which, when the hearse is approaching from the entrance gate to the chapel, may be considered as a part of the burial service. The bell ought to be

placed in a bell turret, rising from one of the gables, so as to become a conspicuous feature, and distinguish the chapel from a cottage, or barn, in the same manner as the chimney tops of a dwelling are characteristic of a human habitation.

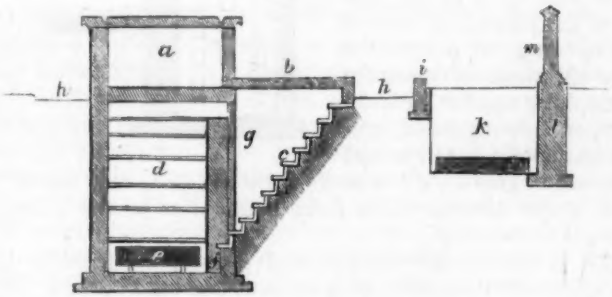
The *entrance lodge* to a cemetery ought to comprise a room to serve as an office to contain the cemetry books, or, at least, the order book and register, and the map book, where, from the system of squares being employed, such a book is rendered necessary. In small cemeteries, and in common churchyards, where the sexton is also the clerk and registrar, all the books, and other documents, will be kept in a strong closet in this room; but, in large cemeteries, managed by a court of directors, the books are kept by a clerk in the cemetery office, in the town, or district, to which it belongs, and only an order book, and the register and map book, or duplicates of them, are kept in the lodge.

Vaults are commonly made under churches, or chapels, but in the large cemeteries they are also made in the open ground, in deep excavations descended to by stairs, and ranged on each side of a passage, or passages, which are lighted through iron gratings on the surface. One of the best examples, on a small and economical scale, is the public vault in the Abney Park Cemetery. The most classical situations for vaults, is in the face of a steep rocky bank, where they require no drainage, and can be entered without descending more than a few steps; such as occurs in the St. James' Cemetery, Liverpool; the Sheffield Cemetery; and the Cathedral, or Necropolis, Cemetery of Glasgow. Catacombs above ground, like those in the London and Westminster Cemetery, like some private tombs in the Kensal Green Cemetery, and like those in the new burying-ground attached to the old church at Brighton, are, in our opinion, in bad taste; since the general idea of burial, no matter by what mode, implies the descent of the body below the surface of the ground. Private vaults for the use of a single family, are commonly made of the width of two or three coffins, and of such a depth as to hold several placed one over the other, commonly with iron bars, or plates of stone between, so that no coffin may have more to bear than its own weight, and the air may be allowed to surround them, to prevent them from rotting. Sometimes each coffin is placed in a separate cell, and closed up with masonry.

Catacombs.—Sometimes the vault is divided into cells like bins in a wine-cellar, by vertical divisions of brick, or stone; and these cells are called catacombs, though the term is frequently applied to a vault, or crypt, not sub-divided into cells. Each cell, when the coffin is inserted, is hermetically sealed, by building it up with brickwork, or inserting a tablet of stone, or marble, inscribed with the name, age, &c., of the deceased. In the new London cemeteries, the cells, or catacombs, are frequently only closed with an open iron grating, the end of the coffin being fully exposed to view. In some cases the cells are literally shelves, and the entire side of the coffin is exposed, as in the West London Cemetery. Both of these modes are attended with gerat danger to the living; whether by the bursting of the lead cof-

fins from the expansion of the gas in the bodies within them, or from its escape through crevices in the lead coffin left accidentally, or through holes made on purpose by the undertaker under the brass plate, as already mentioned. When a private vault is formed on even ground in an open cemetery, steps are made for descending to it; and these steps are commonly covered by a flat stone, level with, or slightly above the surface; or in some cases, as where the steps are under a walk, or path, the stone is concealed under this. Over the vault is placed a monument of some kind, most commonly what is called a square tomb, as in fig 3.; in which *a* is the tomb, or superstructure; *b*, the cover to the steps; *c*, the steps; *d*, the catacombs, or cell; *e*, a coffin placed in the lowest catacomb, and sealed up at *f*; *g*, a door of slate, flag-stone, or iron; and *n*, the grass alleys. In this figure is also shown a common grave, in which *i*, is the foot-stone; *k*, the grave, containing a coffin at bottom; *l*, the basement wall to the head-stone; and *m*, the head-stone.

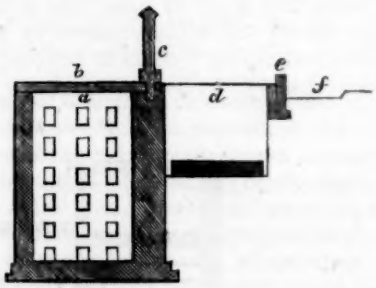
Fig. 3.



A *brick grave* is a substitute for a vault, and differs only from an ordinary grave in having the sides and ends of brickwork, or masonry, and in being covered with a large flat stone, technically, a ledger-stone. These graves are generally purchased and built by heads of families. Sometimes they are of the width of two coffins, but generally of one; and they vary in depth from 10 ft. to 20 ft., or upwards. When an interment takes place, the stone is loosened by levers, and removed by means of rollers; and, the coffin being let down as in common graves, the ledger-stone is replaced and cemented. The side walls are built concave next the grave, in order that they may act as arches against the exterior soil; and, in some cases, they are furnished with ledges which project 2 or 3 inches from each side, for retaining a flag-stone, or slate, between each coffin. When this flag-stone is securely cemented, the coffin below may be considered as hermetically sealed, though it is not very likely that this will be done so completely, as to prevent the ascent of the mephitic gas. In other brick graves no ledges are projected, but one coffin is prevented from resting on another, by inserting two bars of iron in the side walls, so as to support each coffin. When the coffins reach within 3 or 4 feet of the surface, the ledger is put on for the last time; and a putrid mass

of, perhaps, 15 ft. in depth, is left to generate poisonous air, will escape, probably for years, through such crevices as may be left, or as may occur from the action of the weather, or other causes, between the ledger and the side walls on which it rests. The proper mode would be to fill in the uppermost 6 or 8 feet of the grave with earth. The names of the interred are inscribed on the ledger, in the order of their interment; or a monument of some kind is erected on it, of such dimensions, and in such a position, that it can be removed in one piece with the ledger, without being loosened, or otherwise disturbed. In the Highgate Cemetery there are ledger-stones weighing, with their monuments, eight, or ten tons, which are removed all in one piece every time an interment takes place. The more common mode, however, is to place a head-stone as a monument, as shown in the section, fig. 4. In this section, *a* is the side wall of the grave, here shown with openings to permit the lateral diffusion of moisture and mephitic vapour; *b* is the ledger, or covering stone; and *c*, the headstone. At one end is a common grave *(d)* with its footstone *(e)*; and one of the two double green alleys, which form boundaries to the raised panel of graves, is shown at *f*.

Fig. 4.



Brick graves are also used as earth graves, and filled to the surface with soil every time after an interment has taken place. The openings for reinterments should, as we have already mentioned, never be sunk to a greater depth than within 6 ft. of the last deposited coffin; in which case no very great disturbance, or danger, from putrescence would take place, more especially in clayey, or loamy, soil, and when it is made a rule to ram the soil hard with a cast iron rammer, to the height of at least 6 ft. above every coffin as it is deposited.* When the last deposited coffin is within 6 ft. of the surface, the grave should be finally closed. Graves of this kind are not necessarily covered with a ledger-stone; they may be finished with a raised mound of earth, like a common earth grave, or the side and end walls may be finished with curb-stones a foot above the surface, and the interior left level, or planted with flowers. After the last interment, a cy-

* Family graves, in some of the new cemeteries, are made from 12 ft. to 30 ft. in depth. We lately saw one in the Norwood Cemetery, which had been originally 20 ft. deep, and had one coffin deposited in it, after which it was filled in to the surface with soil. It was, at the time we saw it, being opened to the depth of between 18 ft. and 19 ft., and the smell proceeding from the earth brought up, was, to us, intolerable. This, and numerous other cases which we have witnessed, or which have come to our knowledge altogether, independently of the Parliamentary *Report on the Health of Towns*, for 1842, or Mr. Walker's *Gatherings from Graveyards*, have strongly impressed us with the necessity of a law to limit the proximity of one coffin to another in graves in which more than one interment is made, unless, as before observed, the coffins are put in on the same day.

press, or other tree, or a strong-growing herbaceous plant, might be planted in the centre. The walls of graves of this sort should be built with numerous openings, as in fig. 4, to permit the lateral diffusion of the products of decomposition, and of the natural moisture of the soil.

Earth graves are of two kinds: *private graves*, in which only one body is deposited, with, or without a monument; and *common graves*, in which several bodies are deposited, of poor persons, or paupers, for whom no monument is ever put up, except a mound covered with turf, but which ought always to be marked with a stone number for reference, and to prevent all risk of their being opened again at any future period.

To be Continued.

Mechanics and Chemistry.

On certain improvements on Photographic Processes described in a former Communication, and on the Parathermic Rays of the Solar Spectrum. By Sir J. F. W. Herschel, Bart., K. H. F.R.S., &c.; *in a letter addressed to S. Hunter Christie, Esq., Sec. R. S.*

Dear Sir,—I beg leave herewith to submit for your inspection, and that of the Royal Society, a series of photographic impressions, illustrative of the chrysotype, cyanotype, and other processes, an account of which is given in the postscript to my last paper on that subject, which has, by permission of the president and council, been appended to the original in its printed form subsequently to the termination of the session. In the interval which has since elapsed, besides the discovery of other photographic novelties (which may form the subject of future communications), I have been enabled materially to improve some of the processes there described; and these improvements, with a few remarks on some other points treated of in that paper, in relation to the processes in which the thermic rays are concerned, are now subjoined.

The positive cyanotype process described in Arts. 219, 220, of my papers though beautiful in its effect (especially during the first few minutes of the appearance of the picture), is very precarious in its ultimate success, owing to causes there detailed. The remedies proposed are also only occasionally and partially successful, and, in consequence, this process, though exceedingly *easy* in its manipulations, could not be recommended as practically useful. After trying a vast variety of means to overcome these obstacles to its success, I have succeeded at last, by the simple addition of corrosive sublimate to the ammonia-citrate of iron, with which the paper is prepared. The improved process, therefore, may be thus stated. Mix together equal measures of a saturated cold solution of corrosive sublimate, and a solution of ammonio-citrate of iron, one part by weight of the salt to eleven parts of water. No immediate precipitation takes place, and before any has time to do so, the mixture must be washed over paper, (which should have rather a yellowish than a bluish cast,) and dried. It is now ready for use, and I do not find that it is impaired by keeping. To use it, it must be exposed to the light till a faint, but yet

perfectly visible picture is impressed, and till the border (if it be an engraving which is copied) has assumed a pale brown color. Being withdrawn, it is to be brushed over as rapidly as possible with a broad flat brush, dipped in a saturated solution of prussiate (ferrocyanate) of potash, diluted with three times its bulk of gum-water, so strong as just to flow freely without adhesion to the lip of the vessel. All the care that is required, is, that the film of liquid be very thinly, evenly, and, above all, quickly, spread. Being then allowed to dry in the dark, it rarely fails to produce a good picture. And what is very remarkable, it is *ipso facto* fixed as soon as dry, so, at least, as not to be injured by exposure to common day-light, immediately; and after a few days' keeping it becomes entirely so, and will bear strong lights uninjured. By long keeping, details, at first barely seen, come out, and the whole picture acquires a continually increasing intensity, without, however, sacrificing distinctness; and by the same gradations, its color passes from purple to greenish-blue. Some experience, to be acquired only by practice, is necessary to determine the proper moment for withdrawing the photograph from the action of the light. If it be over-sunned, only the darker shades appear; if too little, the whole, though beautifully perfect in the first moments of its appearance, speedily runs into an indistinguishable blot.

The principal obstacle in the way of the employment of gold and silver, as photographic ingredients for the production of negative models, to be used for retransfers, so as to multiply positive copies, arises from the want of absolute opacity in these metals, or their oxides, when in a state of minute division. The same objection does not apply, or applies with much less force, to mercury, which (probably owing to its fluid state, which prevents its particles from acquiring that excessive tenuity which a laminated form would admit, by reason of their capillary forces contracting each separately deposited particle into a sphere) is one of the most opake substances (after carbon) known. I find that this high degree of blackness and opacity may be induced on a mercurial photograph prepared as in Art. 228, by a process which is in itself not a little curious and instructive, as affording a kind of parallel to the stimulating action of Mr. Talbot's second application of nitrate of silver, in his beautiful kalotype process. The nature of the process in question, will be best illustrated by describing the experiment which led to it.

It frequently happens that papers prepared with nitrate of mercury, and the ammonio-citrates, or tartrates, with, or without, addition of tartaric, or citric, acid, fail to exhibit the peculiar properties described in Arts. 228, 229, at all satisfactorily. Indeed, to bring on the peculiar velvety effect there described, a high degree of intensity of sunshine seems to be an essential requisite, as, in a feeble sun, I have never obtained even an approach to it. A paper prepared (Oct. 28, 1842) according to the instructions of Art. 229, in every respect, except in the proportion of tartaric acid (which was somewhat less than that recommended), proved very little sensitive. A strip of this paper, half shaded, acquired after a few minutes' exposure to sunshine, only a feeble brown color over the sunned portion. Being then withdrawn,

it was washed over with nitrate of mercury. *Immediately* the sunned portion began to darken very rapidly, while the shaded part was unaffected, and ultimately assumed a deep brown hue. Exposed while yet wet to the sunshine, this passed rapidly to intense blackness, while the portion originally shaded, which had undergone the same subsequent application, and which was now equally exposed to the sun, sustained in the short time required for bringing on this effect, no appreciable change. Indeed, it seemed rather to have become more insensible than before.

Not alone nitrate of mercury is capable of thus exciting, or stimulating, the dormant photographic impression on such paper. To my very great surprise, I found the same effect to be produced by *water* sparingly applied, so as only to moisten the paper. Across the sunned and shaded portions of a strip of the mercurialized paper, exposed till a pale brown was developed in the former portion, were drawn two streaks, one of weak nitrate of mercury, and one of spring water. Both, after a very short interval, passed to an intense brown on the sunned half, the shaded remaining unchanged. Edging the streak produced by the nitrate, was a black border, that produced by the water, was uniform, The *whole* paper was now exposed for a short time to the sun, which rapidly converted to intense blackness, both the streaks on the previously sunned half, while it produced no perceptible change in the other. I found this experiment to succeed on many different varieties of paper, and with very considerable latitude in the dosage of the ingredients. It was most successful in the case of a paper prepared with a cream, formed by mixing one measure ammonio-*tartrate* of iron (strength $\frac{1}{12}$*) and two saturated protonitrate of mercury, leaving out the free tartaric acid altogether, which, among many other doses of these two ingredients, proved also, generally, the most sensitive to light.

Led by these indications, I prepared a paper by washing, first with a weak solution of ammonio-citrate of iron (strength $\frac{1}{20}$), and when dry, with saturated protonitrate of mercury. It was exposed *when barely dry enough, not to feel damp,* with an engraving in a frame to a hazy and declining sun. In about twenty minutes, a very pale, and feeble photograph was produced. Excited, as above, by water, it gained but little in intensity (for it deserves remark, that the *increase* of apparent intensity, produced by either water, or the nitrate, is in direct *proportion* to the force of the original impression, which, as observed, was in this case very faint.) It was then held for about five minutes in the sun (near setting), and, by degrees, and with the utmost regularity of gradation over every part of the picture, each line assumed an inky blackness, the lights and shades being exquisitely preserved in their due proportions, and the ground being hardly perceptibly discolored. The result was very beautiful, and perfect negative photograph.

This singular power of water to excite the dormant impression, strongly recalls the analogous power of moisture, to deepen the tints

*By this I understand one part (by weight) salt + 11 water.

photographically impressed on auriferous papers, of which an instance is given in Art. 45, and of which a still more striking example is shown as follows. Let a paper be washed first with ammonio-citrate of iron, and when dry with neutralized chloride of gold, and thoroughly dried in the dark. It is then, apparently, almost insensible to light; a slip of it half exposed to the sun being hardly impressed in any perceptible degree in many minutes; yet, if breathed on, the impression comes out very strong and full, deepening by degrees to an extraordinary strength. Treated in the same manner, silver also exhibits a similar property.* Nor, indeed, is there any feature in photography more general, or more remarkable, than the influence exercised by the presence of a certain degree of moisture in favoring the action of light, whether direct, or indirect.

There is this difference, however, in the excitement produced by simple water, and by the mercurial solution, viz., that the latter is permanent, the former liable to fade; at least I have found this to be the case with the brown tinge produced by it in shade, though, when blackened by a second exposure to sun, no difference is perceived. On the other hand, when the nitrate is used, the brown hue frequently passes to absolute blackness, without any subsequent exposure to sunshine; and in that case the photographs produced have an intensity, and opacity, scarcely, if at all, inferior to that of printing ink.

This high degree of opacity and depth, together with the comparative insensibility of the ground, is evidently capable of being most usefully applied to the production of retransfers. In fact, the photographs so produced, being negative, are so far fitted for the purpose, and if used as models while in this, their transition state, and as it were self-fixed, so far from being injured by the transmission of light, they are actually acquiring additional sharpness and depth, by every beam which passes. By *seizing, therefore, the right point of dryness*, and by using a very sensitive paper to receive the impression, there is no reason to doubt of success in procuring very perfect positive transfers. Some trials I have made, have satisfied me as to the practicability of this, however contrary it may at first sight appear to the usual conditions of photography. Lond. & Ed. Philo. Mags.

* Note added Dec. 21.—The excitement is produced on such paper by the ordinary moisture of the atmosphere, and goes on slowly working its effect in the dark, apparently without *other* limit than is afforded by the supply of ingredients present. In the case of silver, it ultimately produced a perfect *silvering* of all the sunned portions. Very singular and beautiful photographs, having much resemblance to Daguerreotype pictures, are thus produced; the negative character changing by keeping, and by quite insensible gradations, to positive: and the shades exhibiting a most singular *chatoyant* change of color from ruddy brown to black, when held more, or less, obliquely. No doubt, also, gold pictures, with the metallic lustre, might be obtained by the same process, though I have not tried the experiment.—J. F. W. H.

Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.

(Continued from Page 124.)

In taking up the subject of heavy green sand moulding, we enter upon an extensive field of practice, and it will be necessary, as before, to select such examples as appear best adapted to present fair, general views of the subject.

In connexion with some observations on the practice of green sand moulding generally, stated towards the conclusion of our last article, we must, in the first place, remark the introduction of a new element, powdered coal, namely, into the sand, in a state of simple mixture; its office, as before remarked, being to assist the blackening in resisting the penetrating action of the iron. As this action exists just so long as the metal continues in a liquid state, the blackening alone proves sufficient to resist it, in cases of light moulding; whereas, in heavy mouldings, there being a much greater body of metal together, its temperature falls so much the less rapidly, and it, of course, continues its action as a liquid for a longer period. Consequently, coal powder in addition becomes necessary to withstand the attack of the iron. But, further, the proportion proper to be mixed is a matter of considerable nicety, and is dependent on two circumstances; first, the length of time that the liquidity of the metal continues, has a simple relation to bulkiness of the metal; secondly, the temperature of the metal on being poured into the mould, does proportionally increase, or diminish the original intensity of the action on the sand, as well as affect the duration of this action. The correct adjustment of this point must be left to the skill of the workman, derived from his previous experience.

A redundancy of coal in the sand renders the surface of the casting formed in it, *faint;* that is, its outlines are imperfectly developed, or, to use again the language of the moulder, the casting is not sharp. This is the natural and obvious effect of the repellent power of the superabundant gas generated by the heat from the coal. On the contrary, a deficiency of coal proves equally hurtful to the quality of the casting, as the gas produced from it is, in this case, too weak to maintain the well-balanced action of the opponent forces. The iron, having burnt through the blackening, penetrates the sand, which, at the surface, becomes incorporated with the metal, and produces, therefore, a peculiar roughness on its surface. In order to make the casting in the most proper manner, the sand and coal-powder should be mixed, not only in a proportion suited to the body of metal to be cast in the mixture, but also as uniformly as possible.

Pease-meal is not generally used in the heavier flat mouldings, its object being to hold down the blackening applied to mouldings of an intricate, or ornamental character. Now the parts of machinery generally have their surfaces plane, which are, therefore, easily accessible to the trowel and sleeker.

For large castings, the bed of sand, which forms the floor of the foundry, is commonly employed for constructing the moulds, serving

thereby the purpose of the *drag-box*. Our illustrative examples shall be drawn chiefly from the structure of a portable non-condensing steam engine of 20 horse power. To begin with the sole-plate, which will be the first, and most instructive example, it is necessary to describe its construction:—

Fig. 1.

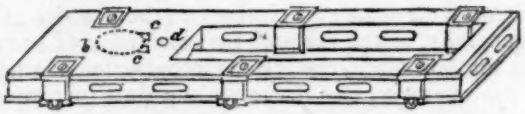


Fig. 2.

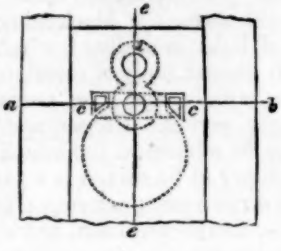


Fig. 3.

Fig. 4.

Fig. 5.

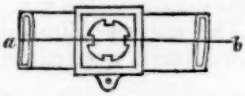


Fig. 6.

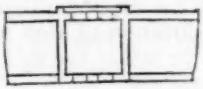


Fig. 1, is an external view of the plate, showing the upper surface. It is arranged to maintain six columns, surmounted by an entablature. At one end, *b*, a platform for supporting the cylinder is cast across the plate, stiffened by a deep flanch at the edge. The position of the cylinder is indicated by the dotted circle. When the cylinder is set in its place, the apertures, *c*, *c*, form continuations of the eduction steam passages; they are joined into one short branch-pipe below the platform. *d*, is a circular passage for the introduction of the steam into the valve chest. It is projected downwards to the level of the mouth of the eduction-pipe, both passages terminating in one large flanch, by which the respective pipes leading to them, are connected.

Fig. 2, is a plan of part of the sole-plate, including the steam-ways, showing, in dotted lines, the eduction passage, and the flanch. Fig. 3, is a vertical section of the sole, and the eduction passage at the line, *a*, *b*, fig. 2. The steam passage also is dotted in behind it. Fig. 4, is another vertical section of the same, at the line, *e*, *e*, fig. 2, showing in section both of the passages, *c*, *d*.

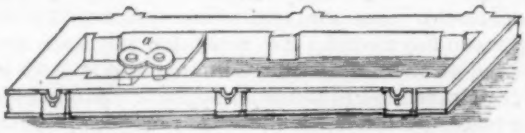
Fig. 5, is a plan of another portion of the sole, showing the foundation for a column; fig. 6, being a vertical section of the same at the line *a*, *b*, fig. 5. It thus appears that the sole is hollow within, and

it possesses the form of section shown in fig. 3, all round, interrupted only by the sockets for the feet of the columns. It is a general practice in founding to dispose of the moulding so as that those parts of the casting towards which the greater quantity of metal exists may be undermost. In this way, greater security is found for the soundness of castings at the more important parts.

Now, the sole-plate is, for the most part, entirely open on the under side, as may be seen on referring to the section, fig. 3; it ought, therefore, to be cast with that side uppermost, according to the preceding statement.

For reasons, which will be better understood as we proceed, the pattern of the sole-plate, of the same form externally, is not made open like the sole, on the under surface. Neither are the oblong blank spaces, shown in the sides, executed in the pattern; its cross section at every point is a complete four-sided figure. This form of pattern, will, of course, leave in the sand a plain open space of the same breadth as itself. *Cores* of sand, of the form of the internal void, must, therefore, be introduced into the moulding, to complete the figure of the casting. The fig. 7, exhibits the under side of the pattern. At *a*, the pattern of the steam ways are placed. They are

Fig. 7.



not fixed to the surface on which they stand, but are simply prevented from shifting laterally by small pins, or snugs. They are made solid, so that they, too, like the plate itself, require to be cored out, and, accordingly, the prints, for securing the cores in their positions, are added to the patterns of the flanch, which itself is attached loosely to the pipe patterns. On the opposite side of the main pattern, prints are likewise fastened to receive the other extremities of the pipe cores. In like manner, prints are attached to the upper side of the pattern, to receive the cores for the column sockets, fig. 6; and to the snugs, *s*, *s*, &c., to core out the holes in them.

A level bed in the sand upon the floor, of sufficient extent, is, in the first place, prepared for the pattern, which is then set down upon it, and well bedded in its place, which is effected by blows given to it over the surface—the object being to form a complete impression of the under surface of the pattern. Sand is farther laid in, and rammed about the pattern on all sides, till it be brought up flush with the upper side, forming thereby the parting surface, on which parting sand is strewed.

The next stage of the process is to lay the upper box, or boxes, over the pattern, and to fix them in their places by stakes of wood driven into the floor, which also guide us to replace them accurately when removed. If there be not a single box large enough to embrace

the whole of the pattern, two, or more smaller boxes, are placed end to end over it, resting upon the sand external to the moulding, and answering the purpose of a single box. The ramming of these boxes is conducted in the usual manner, except at the end, *a*.

Here, it is evident, that as the platform, or cylinder-plate, is now on the under side of the pattern, the body of sand filling the space immediately above it to the level of the upper side, must be lifted out to get the pattern removed. At the same time, the weight of such a deep body of sand adhering to that in the overlying box, would overcome their cohesion, it would break away altogether. As the box is, therefore, incapable of carrying it with it, it becomes necessary to have this load of sand supported by independent means. An iron frame is cast in open sand of the same form as the sunk space, but somewhat smaller, as allowance for the contraction of the casting, in the course of cooling, must be made to allow the plate to be withdrawn, after the casting is executed. In cases where this precaution has not been sufficiently attended to, the jamming of the plate, inclosed on more than one side, has been the natural consequence, and sometimes the destruction of the casting by consequent fracture. In the centre of the frame, a sufficient opening is allowed for the steam ways. This frame is laid in the bottom of the recess, and as its under-surface now faces the moulding, it must be enveloped on that side in the sand, to protect it from the immediate action of the metal afterwards poured into the mould. To assist its adhesion, the frame, or plate, is studded on the under side with numerous tooth-like projections, which are imbedded in the sand applied. Sand is now thrown in above the plate, surrounding the steam ways, and well rammed, its parting surface being made flush with the upper edges of the pattern of the pipe flanch in the centre, and of the contiguous body of sand, forming the interior part of the moulding, their parting being just over the stiffening flanch of the cylinder bottom. With this preparation, the upper boxes, as already said, are set down and filled.

There are prepared six pouring-gates to the moulding, and eight flow-gates. Of the pouring-gates, or those by which the moulding is filled, two are placed along each side, about four feet distant, and two at the cylinder end of the moulding, while none are made at the other end. This unequal division is necessary, on account of the heavier nature of the moulding at the cylinder end; the design of the whole being to have the moulding filled uniformly. The flow-gates are distributed equally over the moulding. These will be again referred to.

Before lifting off the upper boxes, the pattern being now completely moulded, the latter is so far loosened in the sand, that this may not stick to it, and so spoil the operation. This is effected by gentle jolts communicated to the pattern by means of one or more pieces of rod iron, which have been screwed vertically into the pattern before finally ramming the sand in the upper box, or which merely enter into holes in the pattern. These rods being sufficiently long to pass out through the sand when the box is filled, it is upon their upper extremities that the blows of the hammer are given both

horizontally and vertically; the force being regulated by the weight and magnitude of the pattern. The rods, unscrewed if necessary, are now drawn straight out, and the upper box is in readiness to be lifted smoothly off.

After the box is removed, the plate and its overlying core of sand, as it may be termed, deposited in the recess at the cylinder end of the pattern, are lifted out of their situation by arms rising through the core, carrying with them the pattern of the steam ways, which is at liberty to go; for, as we have already noticed, it stands loose on the main pattern. The pattern itself is not in one piece; the flanch, which is separate, is lifted off towards the upper side of the core, and the remainder of the pattern is drawn out by the under side. This is evidently the only mode of extracting the pattern, and shows the necessity in such cases of constructing patterns in two or more pieces to adapt them to the exigencies of the case.

The parts of the mould, in the neighborhood of the pattern, must now, after the box is removed, be pierced with small holes, executed by means of wires traversing the whole body of sand, with the view of rendering the moulding more porous, and of facilitating thereby the escape of the air and other gases. The mould is also watered along the edges, to increase the coherence of the sand.

The pattern itself is taken out by lifting it in all its parts at once, by pins secured into it at several places, so as to be raised in a truly vertical position. This manœuvre is performed by several men, who, while they lift the pattern with one hand, strike it gently, and constantly, with the other, thus continually checking any efforts made by the pattern to tear away the sand of the moulding, and now especially is this remedial application necessary, as the pattern is much more engaged in the lower moulding than in the upper, which, indeed, is the case in mouldings generally. Unavoidable degradation in one, or other, of the two parts of the mould nevertheless do occur, and these the workman repairs with damp sand by means of his trowel.

The moulding is next smoothed all over the surface by the trowel, and a sprinkling of charcoal is then applied, and polished likewise by the trowel. It is, however, omitted for very large castings. Sometimes, also, in order to avoid using too much charcoal, the surfaces are lightly dusted over with sand, finely pulverized through a bag. The moulding is now ready for the reception of the cores, the making and depositing of which claim the particular attention of the moulder, as the figure of the future casting will very much depend upon his accuracy in these respects.

Cores of several forms are necessary for the completion of the moulding. There are, first, the cores for the column sockets, of which there are six; then the cores for the intermediate portions of the sole-plate, of which also there are six, there being two on each side between the socket cores, and one at each end; again, two cores for the steam ways, with several other minor cores, for the holding-down-bolt holes in the snugs at the bases of the columns, as well as for the holes that may be required for the bolting down of pedestals, &c., to the sole. For all these, there are simple prints sprigged upon the pattern at the

proper places, the impression of which in the sand serve to hold the cores securely.

As we have already remarked, about the beginning of our last paper, cores must be made not only of the exact size and shape of the vacancies in a casting, whether partial, or thorough, which they are intended to form; allowance must also be made on them for the core-prints, when these are necessary. This allowance then is provided in the cores of the column sockets, for which there are prints on the under side of the pattern, fig. 7. These sockets go through the sole, and are square in the body, and round at each end, as may be understood on referring to figs. 5, and 6, and to the annexed fig. 8, which is a plan of the moulding, showing the cores in their places.

Fig. 8.

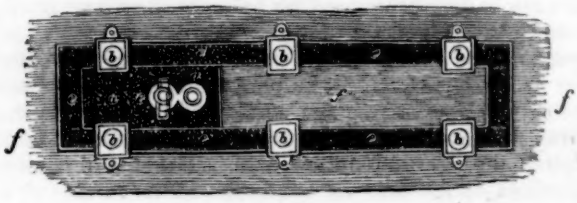


Fig. 9.

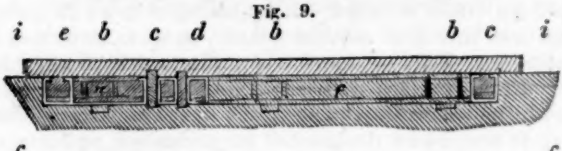


Fig. 9, is a longitudinal section of the moulding, taken through the steam ways. In both figures, *f, f, f,* is the sand of the floor, in which the moulding is formed, constituting the interior, as well as the exterior of it; *b, b,* &c., are the cores of the column sockets, seen in dotted lines in the section; *c, d,* are the cores for the steam ways, which, in fig. 9, are seen projecting in the sand, above and below, filling the recesses made for them by the prints. Figs. 2, 3, 4, explain the shape of them. They are formed in boxes, which open in two, for the purpose of extracting them. These, with all the other small cores, are dried upon hot plates, heated by stoves. At *a,* and *e, e,* &c., the cores are shown, forming the spaces in the moulding intended to be vacant. Near the under side of each, in fig. 9, are shown the plates, indicated by dark lines, which sustain the cores. The whole, however, must be sustained by the bottom of the moulding, leaving a space of the required thickness of the casting. This is effected by placing steeples there; these are simply strips of sheet iron of small lengths, but with double knees, thus [. If the depth of these be just the thickness of the metal, then by placing several of them along the bed of the moulding, they support the cores placed over them, keeping the space clear for the metal—of course, these steeples will be imbedded in the casting, where they are allowed to remain. The double-knee cores at both ends of the moulding, it will be observed in fig. 8, are put to-

gether, each in three pieces. In constructing the cores, *e*, *e*, &c., plain square bodies of sand of the dimensions of the interior of the casting, are, in the first place, formed in boxes of the same size, including, at the same time, the iron frames enveloped in the cores. Now, the small cores that are necessary to the oblong openings in the sides of the casting are simply attached in their proper positions to the sides of the main cores, *e*, *e*, &c. They are formed and fixed on by simply applying upon the larger core, an open box of the form required, into which sand is packed, thus causing it to adhere to the main core; when the box is filled, the sand is squared off by a straight edge, flush with the surface of it. It is evident that if the box be lifted off, it leaves its core behind it. All the other smaller cores having been made, and set in their places, the moulding is finally closed, the upper box being replaced, as seen in section, *i*, *i*, fig. 9. This requires to be done cautiously, and in a truly vertical direction, as it now receives the upper ends of the cores which project above the moulding, and also bears upon the other cores, large and small, which do not require any additional security.

When convenient, two or more gates are connected to one central reservoir, all built on the surface of the sand. Gates at considerable distances from others, are usually supplied separately with iron from hand ladles. The other gates that are connected, are supplied from crane ladles, which are conveyed by cranes from the cupola to the moulding. The ladles will be afterwards described. The flow-gates, while the metal is being formed, are plugged with clay-balls, to "keep down the air" in the moulding. These plugs are drawn out when the moulding is filled, and the iron flows up. It is thus judged whether the casting is complete. The plugs must not be prematurely drawn, as by the too free egress given to the air, the bottom of the mould is apt to be disturbed by the air confined in the sand.

When the metal is poured, the "feeders" are immediately applied at the flow-gates. These are rods of iron, which are plunged into the liquid iron, and wrought up and down in it. By this agitative process, the liquidity of the iron about the gates is longer than otherwise maintained. It is, therefore, enabled to supply itself with additional iron from the flow-gates, for it must be understood that in the cooling down of large bodies of metal, the surface sets, while the interior is liquid; and, therefore, when the interior farther contracts, it draws in the surface metal towards the centre, and if not fed as above described, the casting assumes a vesicular structure, which weakens it considerably. To avoid such a result as far as possible, is the object of the agitation produced by the rod.

(To be continued.)

Jeffery's Marine Glue.

[A recent invention, called Marine Glue, has been produced by Mr. Jeffery, of Limehouse, which demands our attention, as from its extraordinary qualities it is likely to become hereafter of great impor-

tance in the various purposes of ship building. We have taken the following account of it for our readers, from the inventor's description.]

Mr. Jeffery, the inventor of this substance, who was one of the early producers of copper plates by galvanic action, considered that the manufacture of copper sheathing for vessels might be improved by that process. But finding that he could not diminish the cost of production below that of plates made by the ordinary method, and that the waste by oxidation on the one hand, and on the other hand, the mischief of foul bottoms when oxidation was checked, formed insuperable barriers to success in the application of this process, he desisted from the attempt. The idea also occurred of applying gums insoluble in water, as a protection for the bottoms of ships; and by combining elastic gum with non-elastic, and charging the whole composition with ingredients destructive both to animal and vegetable life; that such a coating would protect the timbers from the contact of the water, and also prevent any adhesion, or accumulation of animal, or vegetable matter, and resist the attack of the *teredo navalis*. Mr. Jeffery accordingly made a series of experiments, and succeeded in producing a composition likely to realize all his wishes and expectations. He then deposited a sealed paper, descriptive of his discovery, in the Admiralty, with a statement as to the probable effect of the composition, and, at the same time, several blocks of wood were experimentally sunk in Portsmouth harbor, to prove that the marine glue possessed properties most useful and important for ship building, and other purposes.

Every one knows that the timbers which compose a ship, are exposed to constant strain from winds and waves, from the time the ship is launched until she is broken up. One of the qualities required in a substance used to join those timbers, must be insolubility in water, or it would be useless; it must be impervious to water, so as to prevent leakage; it must be elastic, so as to contract and expand according to the strain on the timber, or the vicissitudes of climate; it should be sufficiently solid to fill up the joint, and give strength; it should be adhesive, so as to connect the timbers firmly together. These properties Mr. Jeffery has combined, in an eminent degree, in the marine glue. One of the experiments made to test the power of this glue, was the following:

Two blocks of African oak, eighteen inches long, by nine inches wide, and four and a-half inches thick, were joined together longitudinally by the marine glue, and a bolt of one and a quarter inch in diameter, was passed through each of them from end to end, and a chain attached to it.

On the next day attempts were made to draw the blocks asunder longitudinally, by means of the hydraulic machine in Woolwich Dockyard, applied to the chain, in the presence of Sir Francis A. Collier, and the master shipwrights of the Royal Dockyards at Plymouth, Portsmouth, Sheerness, Chatham, and Woolwich. A strain, to the extent of nineteen tons, broke one of the bolts, but the junction of the wood by the glue remained perfect. Two bolts of one and a

half inch in diameter, were inserted on the following day into the same block, and the strain was again applied, until it reached twenty-one tons, when one of the bolts was broken; the junction of the wood still remaining perfect, and apparently not affected.

Two blocks of African oak, of similar dimensions, were glued together, with bolts at the opposite ends, so that the strain might be applied at right angles, to the junction made with the glue. With the strain of five tons, one of the blocks split asunder at a short space from the point, but the joint remained perfect.

The result of these last experiments was deemed more extraordinary by those assembled, inasmuch as African oak is a very difficult wood to unite.

Numerous experiments have been made to ascertain the best proportions of the mixture constituting the marine glue for various sorts of wood; and in one case, where it was applied to elm, it resisted a strain equal to 368 lbs. on the square inch. This trial was made whilst the block was in a wet state, which state is considered most favorable for the effect of the glue.

Several large pieces of timber glued together, were precipitated from the top of the shears in the Dockyard at Woolwich, a height of about 70 feet above the ground, on to the granite pavement below, in order to test the effect of the concussion. The wood was shattered and split, but the glue yielded only in one case, in which the joint was badly made, and after the third fall. This falling from a height on to a hard substance, is a very severe test of the strength of a joint. The explosion of a shell has greater power in rending wood, but does not produce so great an amount of vibration.

From the elastic nature of the marine glue, it contracts when the timbers to which it is applied are swollen by water, and expands when the timbers shrink from heat, or any other cause.

A block of wood with a rend in it was taken, and the rend filled with the glue. It was then immersed for a month in a mast-pond at Chatham, at a temperature ranging between 30° and 40° Fahrenheit. On taking it out of the pond, the glue, from the pressure of the wood, was slightly squeezed out, so as to present a raised surface above the rend, but after this block had been a month in the Chatham hoop-house, at a temperature from 70° to 80° Fahrenheit, it assumed a concave figure on the surface of the rend. This block experiment is still going on, and it is intended to place the block in the hoop-house and mast-pond alternately for the space of a year, in order to ascertain whether the result will be equally successful. But in preparing the glue, its elasticity may be increased, or diminished, as circumstances may require.

This quality renders the glue most valuable as a remedy to be applied to the rends and fissures of timber; and, in fact, renders defects of that nature of little consequence—a result, of which the practical shipwright will perceive the immense importance. It is also available with peculiar advantages for the seams of vessels, in lieu of pitch; seams which were payed with it about a year since, and were exposed to the heat of last summer, appear but little changed, and are

quite free from leakage, although they were executed under very unfavorable circumstances. For the deck seams it will be found peculiarly suited; and where it is used the crew will never have reason to complain of the glue sticking to their feet. The surface of the seams after heavy rains, or from a damp atmosphere, will become slightly convex, and under a warm temperature will become slightly concave; but it will not liquefy by solar heat, and it will, under all circumstances, adhere with its original tenacity. All practical seamen will perceive the vast importance, in point of economy, comfort, and security from leakage, which these qualities ensure, especially in hot climates.

Another important experiment has been made with the glue in reference to its being a substitute for copper sheathing. This composition was applied without poison, to four surfaces of some nearly cubical blocks of wood, and on the other two surfaces, it was applied in combination with poison, equally destructive to animal, as to vegetable, life. After the lapse of twenty-three months, these blocks were taken up, and were found to present the following appearances—small shell-fish were adhering to the four unpoisoned sides, whilst the two sides charged with the poison, were perfectly clean. The whole of the composition was slightly changed in color, but was not deteriorated, or affected, in respect of its useful qualities.

Another most important use of the marine glue, is evidently in its application to the construction of masts. Its power of adhesion, and elasticity, admirably fit it for the purpose of joining the spars of which masts are composed. A great reduction of expense is likely to follow its adoption for this purpose, as shorter and smaller timbers may be rendered available, and most, if not all, of the internal fastenings may be dispensed with.

The following account of some experiments on this point are from daily journals. The masts alluded to, have been glued with such proportions of elasticity,given to the glue, which deflect in about the same ratio as the wood itself, or as if the wood were in one solid piece.

"Experiments were carried on, January 4th, and 5th, at Chatham, in the presence of Capt. W. H. Shirreff, Superintendent, and Mr. John Finchman, master shipwright, at the Dockyard, with the marine glue, invented by Mr. Jeffery. The experiments which were carried on last year at Woolwich, with the view of improving its immense adhesive power, and that it would be more difficult to separate the joinings made with it, than it would be to tear the solid wood in pieces, by shots from the large guns of the ordnance, and the result of the trials so convinced the master shipwrights then assembled to consider improvements which might be brought forward for the benefit of the Royal Navy, that they recommended its adoption, and its application to naval purposes was approved by the Lords Commissioners of the Admiralty. The main-masts of the following vessels have been joined with it, under the instructions of Mr. Jeffery. The main-mast of the Eagle, 50-gun ship, was first fitted with it, and it now stands exposed to all the changes of our variable atmosphere; the

main-mast of the Trafalgar, 120-gun ship, built at Woolwich, has been joined with marine glue, and appears to be finished in a most substantial manner; and some idea may be formed of the number of joinings, when it is stated, the dimensions of the mast is 125 feet in length, with a diameter of 40 inches. The main-mast of the Curacoa, formerly a 32-gun ship, but at present being reduced to a 24-gun vessel, is in progress of being joined with the composition. The whole of the practical workmen speak highly of its merits, and have expressed an opinion that its general use will save a great amount of labor in placing internal fastenings, which may now be nearly dispensed with. Mr. Jeffery had an officer from Pembroke Dockyard under his instruction, who returned home with a quantity of the composition to be used in laying the decks of the Victoria and Albert steam vessel, for the especial use of her Majesty, and his Royal Highness Prince Albert.

"The experiments formerly made and tested, were undertaken at a period when a high degree of summer temperature existed, and it was imagined by some, that it would be difficult to use it in winter, so as to have equal adhesive, and strengthening powers. In order to satisfy himself on this point, the inventor had several pieces joined together during the present cold weather, and the following is the result of the trials of their qualities:

"Eight pieces of wood 12 feet long, and 6 inches in diameter at one end, and 5 inches at the other, were each cut lengthways into four pieces, and joined together with the marine glue, two of the pieces with a new sample of the composition, and the others in the usual manner, only varying the proportions of shell lac of $\frac{6}{12}$ and $\frac{9}{12}$. These pieces of wood were alternately attached by strong bolts to the floor of the mould loft; and an iron collar and chain having been placed in the centre, the following weights were placed on a balance to shew the deflection, or strain. No. 1, with the new sample, with a strain of 25 cwt., bent 3 inches exactly, and on the withdrawal of the power, returned to its former position with the greatest elasticity. No. 2, with a strain of 27 cwt., only yielded $2\frac{1}{8}$ inches. No. 3, with a strain of 27 cwt., bent $2\frac{3}{8}$ inches. No. 4, with a stain of 27 cwt., yielded $3\frac{3}{8}$ inches, having been joined by the new sample. No. 5, with a strain of 27 cwt., showed a deflection of $2\frac{1}{8}$ inches. No 6, with a strain of 27 cwt., only yielded 2 inches. No. 7, with a strain of 27 cwt., bent $1\frac{7}{8}$ inches; with $29\frac{1}{4}$ cwt., $2\frac{1}{8}$ inches; with $31\frac{1}{2}$ cwt., $2\frac{1}{4}$ inches. It was then attempted to break this model mast, and additional weights were put on, until it amounted to 45 cwt., when the strain made it yield $3\frac{1}{4}$ inches, and fractured the upper part of the wood, but did not separate the joinings, or thoroughly break the wood, and afforded those present an opportunity of satisfying themselves that the joined pieces were far stronger, in every respect, than solid wood of the same dimensions. No. 8, was tested in a similar manner, and with a strain of 45 cwt., yielded $3\frac{1}{2}$ inches, and at one end the joining opened a little in one direction, which will afford the inventor an opportunity of judging of the best degree of mixture of the various substances of which it is composed. The experiments were

carried on at a temperature of 40 degrees, and that was the height of the thermometer in the mould-loft at the time they were completed, 4 o'clock, P. M. on the 5th, it being only 8 degrees above freezing point. The value of the materials and invention has now been completely established, and its importance to her Majesty's Navy will be very great, as it has hitherto been found very difficult to obtain trees of sufficient length and diameter, about 22 or 23 inches, for main-top-masts for first rates; but they may now be made from any number of pieces, and from the nature of the marine glue, they will never be subject to the dry rot.

Another experiment was made by joining two pieces of wood 9 inches square, by 20 inches long, and placed in such a position that 21 cwt. of iron, forming a pile 6 feet high, about 7 inches broad, and 20 inches long, and it bore the whole weight without yielding at the time. On the second day, the wood gave way under the immense pressure, shewing the cement was more powerful and secure, than the solid timbers." We shall, in a future number, enter into further details of the value to the navy of this important discovery.

The extraordinary utility of the marine glue will not be fully appreciated, until vessels, in the construction of which it has been applied throughout, from the kelson to the main-top, shall have been exposed to disasters in which ordinary vessels would go to pieces, or founder, from leakage. In many such cases the superiority of the marine glue will hereafter be manifested, in the preservation of vessels, together with the property and lives of the persons on board.

No attempt is here made to enumerate the various constructions, such as dock gates, piers, aqueducts, floating bridges, &c. &c., to which the marine glue may be applied with advantage; the present design being simply to point out some of its principal qualities as shown by experiment.

Naut. Mag.

March 25th, 1843.

On the Principles of Aerial Navigation. By Sir Geo. Cayley, Bart.

Sir,—Mr. Henson having now published a description of the ærial machine, with which he proposes to make his experiments, and feeling an earnest desire that success may attend the practical development of principles which, however difficult in execution, are, undoubtedly, true in theory; I trust it will not be thought obtrusive in me to state a few leading observations with reference to the present scheme.

The magnitude of the proposed vehicle, will, I much fear, militate against its success. There appears to be a limit in nature to the convenient application of winged surfaces. We have millions of winged insects; hundreds of the smallest descriptions of birds; but the eagle, condor, and albatross, sail unmolested, as the sole tenants of the loftier regions of the atmosphere; and these, the largest of birds, probably never exceed one hundred pounds in weight. Muscular power and animal heat, appear to bear a direct ratio to the carbon consumed in a given time by the oxygen to which the blood is exposed in the

lungs; and nature seems to have much exceeded her usual animal limits in this respect, purposely to obtain sufficient power for the flight of birds.* The weight of the body of a bird increases as the cube of its linear dimensions, so that if the length be doubled, the weight will be increased eight-fold; and if tripled, twenty-seven fold. But the surfaces of their wings only increase as the squares of their linear dimensions: hence, in this latter case, if the wings keep the same relative proportion to the increased length of the body, as they did in the original size, they would be too small in the ratio of the square of three to the cube of three, or as 9 to 27, being only one-third part of the proper size to give due support to the weight.

Hence, also, if the original proportions are the most convenient, and appropriate, for the degree of leverage against which the muscular power can act—the most suitable for compactness of structure, and for the covering and warmth of the body—then these conveniences must be sacrificed to the necessity of giving three times greater surface to enable the bird to fly; and, in the structure of the albatross, it is said there is an additional joint, to increase its extent of wing. It is difficult, perhaps impossible, for man to trace all the secrets of nature, as to the limiting causes affecting the dimensions of the different species of the animal creation; though we seem, in the present age, to be getting a glimpse of such matters. The particular degree of gravitation towards the earth we inhabit—the exact force of chemical combination between the various particles of matter, and of general galvanic power over each and all, modified, perhaps, by the mechanical properties of leverage and position—probably form the elements taken into consideration by that Divine mind which called all these powers into existence, to fulfil the benevolent purposes of His will. But it is time to return from this digression, to the particular case in point.

Mr. Henson proposes the machine to have a lateral extension of 150 feet, by 30 in width; thus forming a surface of 4,500 square feet. The extent of leverage, however well guarded by diagonal braces, is in this necessarily light structure, terrific. For, although the wings are not intended to be wafted, the atmosphere, even in moderately calm weather, near the earth is subject to eddies; and the weight of the engine and cargo, &c., in the central part of this vast extent of surface, would, in the case of any sudden check, operate with enormous power to break the slender fabric. In the largest birds, the leverage of the extreme points of their wings seldom exceeds 6 feet; whereas, the extent of wing on each side of Mr. Henson's machine, is 75 feet; therefore, every pound in the central part of this fabric, operates with more than eleven times greater effect of leverage, than every pound of weight forming the body of the largest bird.

This consideration shows that in order to obtain a sufficient quan-

* The power of consuming the carbon in the blood, for the supply of muscular activity, and animal heat, is best estimated by a comparative view of the number of times one can breathe in a given time. The horse breathes 16 time a minute; a man 18 times; whereas, a common fowl breathes 30, and a pigeon 34 times a minute, according to Prevost and Dumas, as quoted by Professor Liebig.

tity of surface to sustain great weights in the air, the extension ought not to be made in one plane, but in parallel planes, one above the other, at a convenient distance, so as to form a more compact fabric, with less extent of leverage. The progressive velocity will prevent these planes from interfering with each other, in giving their due support. If, therefore, so large a surface be contemplated for trying this experiment, would it not be more likely to answer the purpose to compact it into the form of a *three decker*, each deck being 8 or 10 feet from the other, to give free room for the passage of the air between them?

This vast surface is all extended in one nearly horizontal plane, which is not the form experimentally proved to give the proper lateral stability to the machine. It was remarked in my last letter, that the surface should be made in the form of the letter V, though of a much more obtuse angle. Extensive principles are often shown by very insignificant means; and every school-boy knows that his shuttlecock, whichever way it may be struck into the air, is never off its balance. Several winged seeds are likewise, on this principle, borne steadily on the air. As very little of the support is lost by this mode of constructing surfaces for ærial navigation, when not carried to excess,—whereas, the security of the conveyance is very greatly increased by it,—it ought not to be neglected in an experiment, quite sufficiently fraught with danger, after every precaution shall have been taken.

Aerial navigation by mechanical means alone, must depend upon surfaces moving with considerable velocity through the air; but these vehicles will ever be inconvenient, not to say absolutely inefficient, if to effect this they must have an elevated point to descend from; for, to be of ordinary use, they must be capable of landing at any place where there is space to receive them, and of ascending again from that point. They should likewise be capable of remaining stationary, or nearly so, in the air, when required.

Very great power, in proportion to the weight of the engine, is necessary to answer these, or, indeed, any of the purposes of ærial navigation by mechanical means alone. It is, in fact, the *sine qua non* of the case; and Mr. Henson will deserve great credit if he be able, by any invention of his own, or combination of the inventions of others, permanently to maintain the power of twenty horses, by an engine not exceeding 600 lbs. in weight. If that gentleman do not deceive himself in this estimate of the power he proposes to use, well directed experiments will soon point out the proper mode of its application.

There can be no doubt that the inclined plane, with a horizontal propelling apparatus, is the true principle of ærial navigation by mechanical means, as it is that of the flight of birds; and although it has been fully investigated, and there is nothing new in it, the principle, has, as yet, remained dormant, for want of sufficient power. This principle Mr. Henson adopts, and the requisite power he proposes to supply.

It is not correctly known at what angle with the line of flight the wings of birds are applied; indeed, this probably varies with the

comparative size of the wing to the weight of the bird; hence no very accurate estimate of the power exerted can yet be made; but, from sundry experiments with inclined planes, it seems probable that for every thousand pounds weight of the ærial vehicle, eight or ten horses' power will be required.

The larger the surface in proportion to the weight, the less velocity it requires for its support; and as Mr. Henson's machine is said to have a surface in proportion to its weight, exceeding that of most birds, its velocity will not be so great as that of birds. Should he, therefore, fully succeed in his project, the velocity of his flight may be taken at something short of that of the crow, which, in calm air, is 24 miles per hour, and is about the ordinary railroad speed. The direct resistance of the car, masts, and rigging, in the construction of ærial vehicles, will, should they ever succeed, probably put a limit to their velocity, not much exceeding 24 to 30 miles per hour.

It has long since been proved, so far as engineering calculations, founded on tolerably well ascertained data, may be trusted, that elongated balloons, made on a very large scale, and of firm, air-tight materials, may be driven through calm air, by engine power, at a velocity approaching the railroad pace, and, by their buoyancy, carry, whether stationary, or in motion, a considerable cargo. Hence, on a great scale, balloon floatage offers the most ready, efficient, and safe means of ærial navigation.

"The enormous bulk of balloons, as compared with the weight they will sustain, causes the *difficulty* of impelling them, with sufficient speed to be of any utility, either by manual, or engine, power; and this *difficulty*, is, by many truly scientific persons, considered as insurmountable, because they conceive that the bulk, which causes the resistance, must ever be commensurate with the weight of engine necessary to propel them by any species of waftage—and, consequently, as it will not do on a small scale, that it cannot on a large one. It is true, that it requires twice as much gas to sustain a 4 horse power engine, as to sustain one of a 2 horse power (with their loads of fuel and water); but it is not true that the larger balloon, though perfectly similar in make to the smaller one, will, when driven through the air at the same velocity, meet with *double* the resistance—if it were so, the case of steering balloons would be hopeless, and on this mistaken ground many think it a vain attempt. This idea, resting at the very threshold of the invention, and which seems to present an insurmountable barrier, when probed and fully investigated, proves to be false, and the investigation leads to an immutable law of proportion between the resistance, and the capacity to carry weight, or engine power, which, on a very large scale, promises the most satisfactory result.

"If balloons of the respective diameters of one and two, both being spherical, be driven through the air with equal speed, the resistance will be as the *surfaces* opposed to the air, and the surface of the largest will be four times greater than that of the smaller, and hence it will require *four* times the engine force to keep up the velocity;

but the quantity of gas contained in the larger balloon is *eight* times greater than that in the smaller, hence it could sustain eight times as much engine power; but four times that power would keep up the required velocity, and hence it could carry a cargo of the weight of its engine, and yet keep pace with the smaller balloon. The simple terms of the case are, that the surfaces (and hence the resistances) increase as the *squares* of the diameter of the balloon; whereas, the capacity to contain gas (and hence the supporting power) increases as the *cubes* of the diameter.

"From this *unquestionable* law it follows, that if similar shaped balloons vary in diameter as the numerals, 1, 2, 3, 4, 5, &c., the resistance they will meet with in the air, at the same velocity, when compared to the weight (or engine power) they will sustain, will be as 1, ½, ⅓, ¼, ⅕, &c. This is a most important fact, and proves that as the law of relative diminution to resistance is *unlimited*, there must ever be, *theoretically*, some bulk in which any species of first mover, however sluggish in proportion to its weight, would find itself suspended, and its power adequate to propel that bulk with the velocity required."*

Elongated balloons of large dimensions, thus offer greater facilities for transporting men and goods through the air, than mechanical means alone, inasmuch as the whole weight is suspended in the air without effort; and when the invention is realized, it will abundantly supply the increasing locomotive wants of mankind, for which, in due time, it was probably designed. Mechanical flight seems more adapted for use on a much smaller scale, and for less remote distances; serving, perhaps, the same purpose that a boat does to a ship, each being essential to the other.

One great difficulty to be overcome in mechanical flight, is the enormous difference of the powers required to perform it, as birds do, by any direct downwards waft in the first instance, as compared with the skimming action on the principle of the inclined plane. The surface of a square foot, if loaded, as it is in the crow, with a pound weight, would descend perpendicularly with a velocity of 21 feet per second; hence, to sustain his weight, he must press his wings down with that velocity, which is equivalent to lifting his own weight 21 feet per second. Now, if an ærial machine were to weigh 1000 lbs., and it had to be lifted with this velocity, the force required would be that of 38 horses; and Mr. Henson's engine, if loaded in the same ratio, would be a 114 horses' power. The bird even exerts a still greater effort, for he has, in the downward beat, to make good the time lost in the ascent of his wing.

The crow, in skimming, goes about 36 feet per second; during which time, if unaided by any waft to propel him, his descent will be about one-eighth of 36, or 4½ feet. The power required, therefore, cannot be greater than in the ratio of 4½ to 21; and in this case 1000 would, in the skimming action, require a 8¼ horses' power, to main-

* From Practical Remarks on Aerial Navigation, by the author of the present article, in *Mech. Mag.*, for March 4, 1837.

tain it, provided it were performed as in birds, by the surface being moved downwards, when obliquely raised at the hinder portion, so as to continue during this action, the same force of the air applied under the surface, as when the front portion of it is elevated, and the bird skims for a time by its previously acquired momentum. It is not yet ascertained what the actual angle of the bird's wing is, and the absolute power required for propelling ærial vehicles, cannot, therefore, be stated with certainty, though we thus make some tolerable approximation to the truth.

Fig. 1.

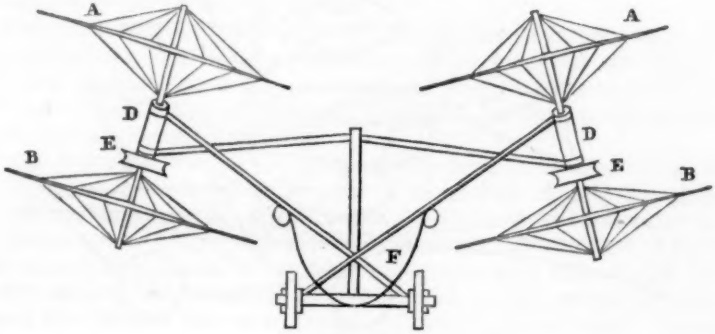
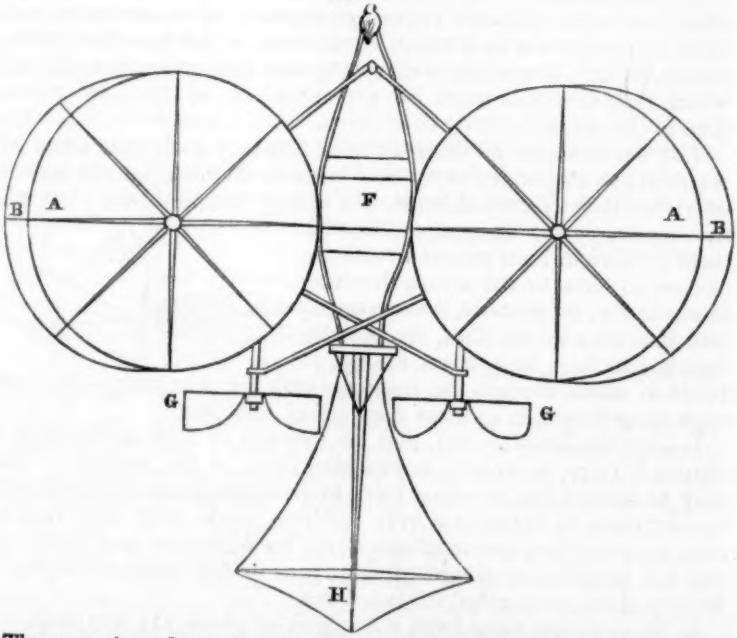


Fig. 2.

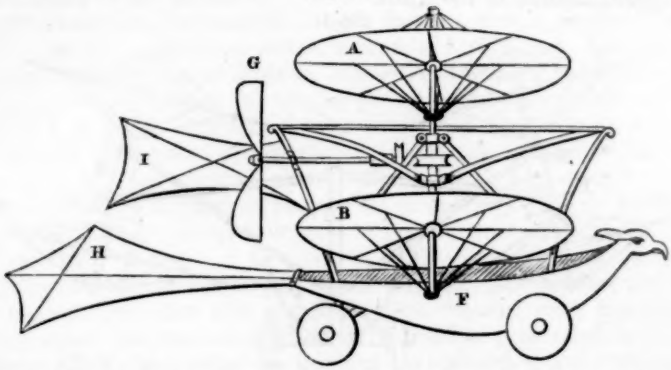


The capacity of varying the degree of power to so great an extent in muscular action, gives much greater facility to the flight of birds

than man possesses in his steam power, the uniformity of which obliges some more uniform course of action to be adopted.

Under this general view of the case, I have endeavored to combine all the requisite principles of action that have been enumerated. Fig. 1, 2, and 3, will exhibit, without tedious explanation, the construction of an ærial vehicle, containing about 530 square feet of surface. Fig. 1, shows an end view in elevation; fig. 2, a bird's-eye plan; and fig. 3, a side elevation.

Fig. 3.



The main surfaces, A, A, and B, B, are here placed one above the other, and each pair are connected together by strong shafts, firmly fixed into sockets at each end of a steel axis, which turn freely in their collars, D, D. These shafts carry a spiked pulley, or drum, E, E, by which they may be turned by a pierced belt, or chain, from the engine in the car, F.

The construction of these circular planes is such, that when only required as a stationary expanse of surface, they continue in one even, or rather slightly curved, state, like a very flat umbrella; but when the engine power is applied, to make them revolve in their proper directions, one set adverse to the other, they are immediately, by that act, thrown open, into the form of the flier, fig. 4, and thus the surface, to a great extent, is made to skim, though the machine may be stationary—the upper edge of each section in these fliers being foremost.

Fig. 4.

It must also be observed, that the two sets of fliers are placed in the obtuse V form, to ensure lateral steadiness to the machine. These may be termed the elevating fliers, to distinguish them from two other smaller ones, G, G, set at a very different angle with their axis, and used for propelling the machine, when the others are stationary; both sets will be put into action gradually, or in any required degree, by friction plates, as is usual in such cases.

If the elevating fliers have a diameter of about 11¼ feet each, they will contain about 100 square feet of surface; yet by this construction, the leverage of the centre of their support, on each side, will

only be about 8 feet from the centre of the car, and this will be firmly sustained by the diagonal bracing of the framework.

The framing is also adapted to increase the stationary surface, by being covered with canvas in the obtuse V form down to the edge of the car, and overhead, like a very flat roof, to keep off rain, &c. This surface, as here shown, would be about 130 feet, but, by the addition of a couple of light yards, as in the sails of ships, it might be much increased, with little additional weight.

The broad horizontal rudder, or tail, H, capable of being turned on its hinge to any angle, at pleasure, gives the power of ascent, and descent, when the propellers are used, and forms also the chief means of stability in the path of the flight.

The small vertical rudder, I, is for the purpose of lateral steerage in combination with the two propellers, which, by being used singly will turn the machine with great power; and if one be reversed by the same means as those now used for steam paddles, a still greater lateral guidance can be obtained.

This construction of an experimental machine for mechanical ærial navigation, is not offered in the light of a finished model; but more to show, in combination, certain principles which must be attended to in their construction, to give them a fair chance of success. It will give me much pleasure, if anything experience may have taught me on this subject, can be turned to any account in the present project, which Mr. Henson has now made his own by patent right. I am, however, of opinion, that balloon navigation is that designed for the uses of mankind, on the large scale; but as this letter has already far exceeded its due limits, I must refer such of your readers as may choose again to examine the capabilities of balloon floatage, to an article in No. 708 of your Magazine for 1837. I think it a national disgrace, in these enlightened locomotive times, not to realize, by public subscription, the proper scientific experiments, necessarily too expensive for any private purse, which would secure to this country the glory of being the first to establish the dry navigation of the universal ocean of the terrestrial atmosphere.

April 2, 1843. Lond. Mech. Mag.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

On the Strength of Cylindrical Boilers. By Thos. W. Bakewell.

I have just received the July number of the Journal, and hope this short piece may be in time for that of next month.

I should have no objection to make to the analysis of E., could his premises be admitted "mais voila l'embaras," he assumes the parallelism in action of the steam peculiar to the received theory, which, in this instance, is vertical. Referring to the diagram of E., in the July number,* let the half section, A, B, D, terminate at A, and B, by being at those points attached to a solid body, occupying the space below A, B. Now, this change will not, in the least, effect the deductions of E.; for, on the received theory, the tendencies to rupture at D, the leverage = D, A, and the turning point at A, remain un-

* Page 54.

touched; and, if, instead of the half section of boiler above A, D, a strong bar were placed parallel with, and at a small distance from the solid body, A, D, connected to it at each end, by a flexible material, the solution of the parting force at D, would still hold, by a slight variation in the definition of terms.

With the half section attached, as above, to the solid body, the operative force to rupture at D, would, on both theories, be as the semi-diameter; and, at B, by the received theory, as the semi-radius: whereas, I contend, that the solid body below A, B, has not effected any change in the conditions of the point, B, which would receive a strain to part horizontally, equal to the quarter circle.

Should, what I have stated, or may state, on this subject, be thought of sufficient importance to induce a trial by experiment, a semi-circle of a flexible material, as here represented, attached to a solid body, would be the simplest method, and form the strongest contrast in testing the two theories; for, at B, the difference would be as 1 to 3.14; or, by the received rule, the semi-circle would uniformly part at A, or B, and by mine, at B.

Cincinnati, 30th July, 1843.

ERRATA.

Page 102—20th line, for "*greater*," read "*quarter.*"
" " 26th " "*greater*," " "*quarter.*"
" " " " "*directions in one*," read "*directions; to be resisted in one.*"
" 104—20th " "*pursuaded*," read "*persuaded.*"

Experiments on the explosive force of Oxygen and Hydrogen gases.

By James Johnston, Esq.

In 1841 I took out a patent for obtaining motive power from the explosive, and condensing properties of oxygen, and hydrogen gases. In order to ascertain the power and length of stroke which those gases would give when exploded in a cylinder, I commenced, on the 24th of April, 1841, a set of experiments, of which I now give the results.

The apparatus with which I made the experiments, consisted of a strong cast-iron cylinder, accurately bored, so that its diameter was exactly two inches and thirteen-sixteenths of an inch. This diameter gives a surface on the piston of six square inches.

The piston was fitted very accurately into the cylinder. I have ascertained it to work perfectly air-tight. On the top of the piston, there is a cross-head, and spindle, for placing weights upon. The ends of the cross-head work in cast-iron guides.

The gases are admitted to the cylinder by stop-cocks, and are exploded by an electric spark.

I shall now describe the preliminary arrangements made before making each experiment.

I ascertained the weight of the piston, piston-rod, and other appendages, which the gases must move when the piston is put in motion, to be 9 lbs. 5 oz.

I then ascertained, that, to overcome the friction of the piston, it required 5 lbs. 1 oz., together with its own weight; therefore, add 5

lbs. 1 oz. to 9 lbs. 5 oz., and we have 14 lbs. 6 oz., the weight, or force required to overcome the friction of the piston.

I now proceeded to load, as follows, the piston, so that I would give the gases 5 lbs. per square inch of weight to lift.

Weight of piston,	9 lbs. 5 oz.
Amount of friction of piston,	14 " 6 "
Amount of weight required to make up the 5 lbs. pr. sq. in.,	6 " 5 "
To weight.	30 lbs. 0 oz.

This gives 5 lbs. per square inch of weight, as there are six square inches of surface on the piston.

I measured the gases in the cylinder by the height to which I raised the piston. Every inch of distance between the bottom of the cylinder, and the bottom of the piston, holds six cubic inches. When making the experiments, I always raised the piston to the height which I wished it to be at, by placing under the ends of the arms of the cross-head pieces of wood made for the purpose. After the piston was thus raised to its required height, the apparatus was ready for the explosion, as the gases were admitted at the pressure of the atmosphere at the time the piston was raised.

The gases were kept ready for use in a bladder mixed in the proportions of two parts of hydrogen, to one of oxygen.

Having described the arrangements for insuring accurate experiments, I now give the results in the following table, of which the first column gives the quantity of gas in cubic inches, which was placed in the cylinder at each experiment.

The second gives the weight that was placed on the piston in pounds per square inch of its surface.

The third gives the height in inches, and tenths of inches to which the explosion drove the piston.

The fourth gives the height of the barometer at the moment each experiment was made.

The fifth gives the height of the thermometer at the same time.

Gas.	Weig't.	Height. In.	Ten.	Bar.	Ther.	Gas	Weig't.	Height. In.	Ten.	Bar.	Ther.
6	5	1	8	29.4 1/2	53 1/2	21	20	2	7	29.5 3/4	54 1/2
9	5	2	9 1/2	29.4 1/2	53 1/2	6	25	0	3	29.5 3/4	54 1/2
12	5	4	4 1/2	29.4 1/2	54	9	25	0	4 1/2	29.5 3/4	54
6	10	1	0	29.4 3/4	54	12	25	0	8	29.5 3/4	54
9	10	1	8	29.4 3/4	54	15	25	1	1 1/2	29.5 3/4	54
12	10	2	5 1/2	29.4 3/4	54	18	25	1	4 1/2	29.5 3/4	54
15	10	3	6 1/2	29.4 3/4	54	21	25	1	7 1/2	29.5 3/4	54
6	15	0	7	29.5	54 1/2	24	25	2	2	29.5 3/4	54
9	15	0	9 3/4	29.5	55	6	30	0	1 1/2	29.7 1/4	57
12	15	1	6	29.5	55	24	30	1	1	29.7 1/2	57
15	15	2	1 1/4	29.5	55	24	45	0	3 1/4	29.8 1/2	52
18	15	2	8 1/2	29.5	55	24	50	0	1 3/4	29.1	43
6	20	0	3 3/4	29.5 1/4	54 1/2	24	55	0	1	29.1	44
9	20	0	7 1/4	29.5 1/4	54 1/2	24	60	0	0 3/4	29.0	45
12	20	1	1 1/2	29.5 1/4	54 1/2	24	65	0	0 1/16	29.0	45
15	20	1	5 3/4	29.5 1/4	54 1/2	24	70	0	0 1/40	29.0	45
18	20	2	2	29.5 3/4	54 1/2	24	75		0 1/40	29.0	45

In the last experiment, viz., that in which twenty-four cubic inches of gas were exploded under a load of seventy-five pounds per square inch, the explosion was unable to lift the piston; it merely shook the weights.

The above table gives the maximum results of upwards of two hundred trials, or experiments, which I have made on the explosive force of the mixed gases.

In order to show that there is an unaccountable irregularity in the results of my experiments on the gases, I shall now give a few experiments which were made with the same gases, and under the same circumstances.

Gas.	Weig't.	Height.	Bar.	Ther.	Gas.	Weig't.	Height.	Bar.	Ther.
		In. Ten					In. Ten.		
6	5	1 4½	29.4½	53½	6	5	1 5½	29.4½	53½
6	5	1 5	29.4½	53½	6	5	1 7½	29.4½	53½
6	5	1 3½	29.4½	53½	6	5	1 8	29.4½	53½
6	5	1 3	29.4½	53½	6	5	1 5	29.4½	53½

In the above eight experiments between the maximum and minimum rise of the piston, there is a difference of five-tenths of an inch. How this difference arises I am at a loss to know. A difference of about the same extent existed throughout all my repetitions of experiments. I have bestowed a great deal of labor, and attention, to find out how this difference arises, and I am satisfied that it has not its origin from any defect in my apparatus, or arrangements. I believe it arises from the difference of strength that may exist between the different sparks of electricity with which the gases were exploded, as it was with the spark from a Leyden jar with which I exploded the gases. I intend making a set of experiments, in order to ascertain this point.

When commencing those experiments, I attempted to explode the gases by the spark which is formed when contact is broken between the wires of a battery; but I found that this spark, although very bright, would not explode the gases. The battery which I used for this purpose, was composed of eight narrow cast-iron troughs, with a plate of zinc in each, measuring twelve inches square.

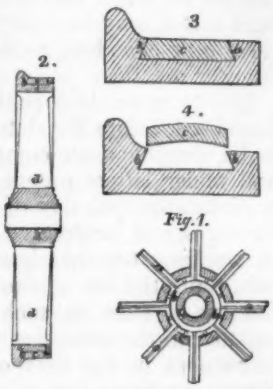
Willow Park, Greenock, 15th March, 1843. Edin. New Phil. Journ.

English Patents.

Specification of a Patent granted to Thomas Banks, of Manchester, in the county of Lancaster, Engineer, *for certain improvements in the construction of Wheels and Tires of Wheels, to be employed on Railways. Sealed 13th June,* 1842.

These improvements in the construction of wheels, to be employed upon railways, consist, firstly, in a peculiar method of constructing the nave, or boss, of such wheels, for the purpose of securely fastening the wrought iron arms, or spokes, in the nave, and preventing their becoming loose.

Fig. 1, is a section, taken vertically through the nave of a railway wheel, constructed according to this improvement. The wrought iron arms, or spokes, are shown at *a*, *a*, which may be formed according to any of the well known plans already in use. These spokes, or arms, are then to be welded, riveted, or otherwise securely attached, to a wrought iron ring, *b*, *b*, and then the boss, or nave, *c*, *c*, is formed by casting, or running, melted metal entirely around the ring, *b*, so as to embrace and inclose the inner ends of the spokes, *a*, *a*, and the ring, *b*, *b*, as shown in the figure.



By securing the wrought iron arms to a ring of wrought iron, previously to casting the metal around the ends of such arms to form the nave, or boss, an increased security will be given to the arms in the nave, or boss, and greater strength and durability will be obtained.

The second part of the improvement consists in placing, or inserting a hoop, bar, or segments of steel, iron, or hard metal, in a groove, turned, or otherwise formed, entirely around the outer rim, or periphery of a railway wheel, such groove being properly shaped to receive the steel, or other hard metal. Fig. 2, represents a section, taken transversely through a railway wheel. *d*, *d*, *d*, represent the rim, or periphery, arms, and nave. The improvement consists in forming a groove, *b*, *b*, either dove-tailed, (as shown in the figure, or otherwise,) shaped entirely around the outer rim, or periphery, whatever the material of the wheel; and in placing, or inserting, therein a hoop, bar, or segments of steel, iron, or hard metal, either in one entire piece around the circumference of the wheel, or in smaller pieces, or segments, placed together, end to end, so as to fill the groove formed round the periphery of the wheel. Fig. 3, represents, in section, a portion of the felly, or rim, and tire of a railway wheel; and fig. 4, is a similar section, excepting that in the latter, the steel bar, hoop, or segment, *c*, is represented as about to be placed in the groove, *b*, *b*; which groove is shown as it is cut or formed in the felly, or rim, previously to the steel being inserted. The bar, hoop, or segments of steel, or other hard metal, being heated, are introduced into the groove, and spread laterally, so as to fill, or become tight in the groove, by hammering, or other pressure, as represented in fig. 3.

Steel, or other hard metal, as above described, may be applied to the working surface of the flanch of the tire. A separate groove may be made in the flanch, or the groove shown in the drawing may be extended further towards the flanched side of the wheel, so as to steel that part of the flanch on which the friction, against the edge of the rails, principally takes place. In applying this improvement to the tires of wheels, whether new or old, made according to the usual method, it will be necessary to form the groove to the requi-

site size and shape; or, if a groove be left, when the tire is formed, it may be enlarged, according to the wishes of the manufacturer, to receive the steel; and the above mentioned hoop, bar, or segments of hard metal, may be easily removed when worn, and renewed from time to time, as long as the general fabric of the wheel is sufficiently firm for use.

The patentee, in conclusion, states that he is aware of steel having been used, before the date of his letters patent, for the tires of wheels, to be employed on common roads and railways, by other persons, and under letters patent, granted to Daniel Gooch, bearing date on, or about, the 28th day of May, 1840, for the use of steel in wheels for carriages, and locomotive engines, to be used on railways, by forging, or welding, together bars of iron and steel; that he does not, therefore, claim the use of steel generally on tires for railway wheels, or the use of steel on such tires, when the iron and steel are welded together in the formation of the tire-bar; but he does claim the improvement in the tires of wheels, to be employed on railways, by inserting a hoop, bar, or segments of steel, or other hard metal, in a groove, turned, or formed, entirely round the rim, or tire, of such wheels as above described.—[Enrolled December, 1842.]

Lond. Journ. Arts & Scien.

Specification of a patent granted to JOHN MULLINS, of Battersea, Surrey, *for certain improvements in making oxides of metals, in separating silver, and other metals, from their compounds with other metals, and in making white lead, sugar of lead, and other salts of lead, and salts of other metals. Patent dated October* 27, 1842; *Specification enrolled April* 27, 1843.

Mr. Mullin's improvements are six in number.

First, he produces oxides of lead and other metals by forcing currents of atmospheric air, or oxygen gas, through masses of the metal in a melted state, "heated to the temperature of their respective points of oxidation," and then skimming off the oxides from the surface.

Second, to make white lead, he exposes the oxide of lead obtained by the preceding process, which is stated to be much superior to the ordinary litharge, and vitrified massicot of commerce, to the vapors of vinegar, and carbonic acid gas. Or,

Third, he exposes a solution of acetate of lead, or other suitable salt of lead, made from "the oxide obtained as aforesaid," to an atmosphere of carbonic acid gas. We quote at length the patentee's description of the mode in which this is effected; it is new, ingenious, and, we think, likely to answer well.

"In chambers, or large jars, of earthenware, or other material, are suspended several large sponges, which are supported in the jars by strings of worsted, so as not to touch the sides of the jar, or one another. Having made a saturated, filtered, and neutral solution of acetate of lead, or of other suitable salt of lead, from the oxide ob-

tained as aforesaid, and placed this solution in a vessel above the top of the jars, and having moistened slightly the sponges with the solution, and also the worsted strings suspending them, the strings are then made to dip into the solution contained in the vessel above the jars, and, by the power of capillary attraction, the sponges are kept constantly moist by a supply of the solution descending down the worsted strings; and the supply can be regulated at pleasure by the size of the strings, or otherwise. Evaporation is continually going on, and crops of salts of lead are formed on the surface of the sponges. The jars are made to communicate with a gas-holder, or other reservoir, containing carbonic acid gas, which gas is made to fill the jars, in order that the sponges may be surrounded with an atmosphere of carbonic acid gas. By the action of the gas, the salt of lead on the sponges is readily converted into ceruse, assisted, probably, by the decomposition of the acid of the original solution. When it has been ascertained that a sufficient quantity of the ceruse has been formed, the sponges are removed, and washed in a vessel of pure water; and if the sponges contain any undecomposed soluble salt of lead, which is generally the case, the water dissolves it; but the ceruse falls to the bottom, on the water remaining at rest. The water is to be reused for forming the solution when decanted from the precipitated ceruse. The sponges are then replaced as before, and the process continues."

Fourth, he employs common soot to deoxidize his oxide of lead, and generally for the reduction of all metals from their ores, or oxide.

Fifth, when a mass of melted lead, treated by the process just described, contains any silver, the silver, being less oxidizable than the lead, accumulates at the bottom of the pot, whence it is drawn off occasionally to be farther purified and separated.

And *sixth*, to separate iron, the oxides are discharged down a shoot, fixed at an angle of about 30°, formed of wood, or some other non-conducting material, from the bottom of which the poles of a number of magnets project upwards, and to which a slow, lateral, sieve-like motion is given by machinery; the magnets attract and retain the iron, and the oxides pass free.

Lond. Mechanics' Mag.

METEOROLOGICAL OBSERVATIONS FOR MAY 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barometr. Sun Rise.	Barometr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	48°	62°	29.30	29.72	W.	Moderate		Clear.	Flying clouds.
	2	38	59	30.06	30.14	W.	do		Clear.	Clear.
	3	46	54	30.20	30.24	SE. NE.	do		Cloudy.	Cloudy.
	4	40	64	30.24	30.24	NE. S.	do		Clear.	Clear.
	5	47	65	30.20	30.20	SW. E.	do		Par. cloudy.	Clear.
	6	44	67	30.20	30.20	SE. S.	do		Cloudy.	Par. cloudy.
☾	7	56	68	30.00	29.86	SW.	Brisk	.67	Par. Cloudy.	Shower.
	8	60	70	29.80	29.80	W.	do		Cloudy.	Flying clouds.
	9	52	70	29.88	29.95	NW.	Moderate		Par. Cloudy.	Par. cloudy.
	10	50	49	30.06	30.06	NE.	do	.38	Cloudy.	Rain.
	11	46	56	29.96	29.95	NE.	do		Cloudy.	Cloudy.
	12	48	76	29.90	29.90	E.	do		Clear.	Clear.
⊗	13	52	80	29.83	29.83	W. SW.	do		Par. Cloudy.	Par. cloudy.
	14	54	80	29.80	29.83	SW.	do		Clear.	Clear.
	15	60	82	29.80	29.80	SW.	do		Clear.	Light clouds.
	16	60	79	29.70	29.80	W.	Brisk		Clear.	Clear.
	17	58	61	29.85	29.96	W.	Moderate		Clear.	Cloudy
	18	47	64	30.10	30.10	NE.	do		Cloudy.	Cloudy.
	19	49	71	30.10	30.00	E.	do	.01	Par. cloudy.	Rain.
☽	20	50	70	29.85	29.80	E.	do		Cloudy.	Par. cloudy.
	21	46	75	29.66	29.60	SE. W.	do		Hazy.	Hazy.
	22	52	75	29.60	29.60	W.	Brisk	.06	Hazy.	Rain.
	23	55	74	29.65	29.65	W.	do	.12	Par. cloudy.	Rain.
	24	52	71	29.70	29.70	W.	do		Clear.	Clear.
	25	49	70	29.75	29.75	W.	do		Clear.	Clear.
	26	52	74	29.80	29.90	E SE.	Moderate		Lightly cloudy.	Light cloudy.
	27	54	68	29.78	29.78	N.	do	.06	Rain.	Cloudy.
	28	53	65	29.86	29.86	SW.	do		Cloudy.	Cloudy.
☉	29	48	54	29.65	29.65	SE.	do	.74	Rain.	Rain.
	30	48	71	29.65	29.65	W.	do		Clear.	Clear.
	31	56	60	29.55	29.61	W.	do		Cloudy.	Cloudy.
		51.29	67.87	29.85	29.82			2.04		

Thermometer. Maximum 82 on 15th. Minimum 38 on 2d. { Mean, 59.58

Barometer. Max. 30.24 on 3d. & 4th. Min. 29.30 on 1st. { Mean 29.835

JUNE, 1843.

Moon.	Days.	Therm. Sun Rise.	Therm. 2 P.M.	Barometr. Sun Rise.	Barometr. 2 P.M.	Wind. Direction.	Wind. Force.	Water Fallen in rain	State of the Weather, and Remarks.	
	1	42°	57°	29.75	29.85	W.	Moderate		Lightly cloudy.	Lightly cloudy.
	2	38	64	30.05	30.05	W.	do		Clear.	Clear.
	3	57	77	29.80	29.75	SW.	Brisk	.25	Cloudy.	Rain.
	4	62	75	29.75	29.75	W.	Moderate		Cloudy.	Par. cloudy.
☾	5	67	86	29.65	29.66	W.	Brisk	.30	Cloudy.	Par. do.—rain.
	6	64	73	29.63	29.70	W.	do		Cloudy.	Clear.
	7	54	72	30.00	30.05	W.	do	.1	Clear.	Clear—rain.
	8	59	75	30.10	30.06	S.	Moderate		Lightly cloudy.	Clear.
	9	64	86	29.85	29 80	W.	Brisk		Par. cloudy.	Clear.
	10	70	87	29.70	29.64	W.	do	.18	Cloudy.	Rain.
	11	75	70	29.60	29.65	SW. W.	do		Cloudy.	Par. cloudy.
⊗	12	55	76	30.02	30.05	W.	do		Par. cloudy.	Cloudy.
	13	56	75	29.85	29.76	SW.	Moderate		Cloudy.	Clear.
	14	67	84	29.60	29.65	W.	Brisk		Clear.	Clear.
	15	56	78	29.70	29.70	W.	Moderate	.12	Rain.	Par. cloudy.
	16	64	82	29.76	29.70	W.	Brisk	.06	Cloudy.	Rain.
	17	60	74	29.85	29.86	NE.	Moderate		Clear.	Clear.
	18	52	72	29.95	30.00	W.	do		Clear.	Clear.
☽	19	56	76	30.06	30.00	SW.	do		Clear.	Clear.
	20	52	78	30.20	30.24	W.	do		Clear.	Clear.
	21	54	82	30.14	30.14	W.	do		Clear.	Clear.
	22	68	81	30.00	29.95	W.	do		Rain.	Par cloudy.
	23	66	85	29.90	29.85	W.	Brisk		Clear.	Clear.
	24	70	88	29.70	29.70	W.	do	.1	Clear.	Clear—shower.
	25	68	82	29.70	29 80	W.	Moderate		Par. cloudy.	Clear.
	26	64	87	29.86	29.87	W.	do		Par. cloudy.	Par. cloudy.
☉	27	70	88	29.86	29.88	W.	do		Clear.	Par. cloudy.
	28	75	81	29.84	29.79	SW.	do		Cloudy.	Cloudy.
	29	71	85	29.75	29.75	W.	do		Clear.	Par. cloudy.
	30	70	87	29.78	29.70	N.	do		Clear.	Clear.
		61.53	78.77	29.85	29.85			.93		

Thermometer. Max. 88. on 24th. & 27th. Min. 38. on 2d. { Mean, 70.15

Barometer. Max. 30.24 on 20th. Min. 29.60 on 11th & 14th. { Mean 29.85